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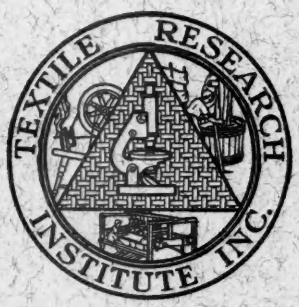

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TEXTILE RESEARCH JOURNAL

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Harold DeWitt Smith, His Life and Works

J. H. Dillon*

An address honoring the memory of Harold DeWitt Smith, presented at the American Association for the Advancement of Science Conference on Textiles, New London, New Hampshire, July 10, 1947.

IT is my sad responsibility to remind you that Dr. Harold DeWitt Smith will be unable to attend this conference and that the paper † which he was scheduled to deliver on this program will never be presented here or elsewhere. It was my privilege and pleasure to know Harold DeWitt Smith, although not so well or for so long as many of you did. Hence, I deem it a great honor to have this opportunity of discussing with you his life and a few of his accomplishments.

Harold Smith, the man, was inseparable from Harold Smith, the scientist. A compilation of his many published scientific works would constitute a story of achievement in itself; yet that story would be manifestly incomplete without a knowledge of the man, his boundless enthusiasm, courage, kindly understanding, and simple honesty. Above all, Harold Smith was a modest man. He would certainly object strenuously to the devotion of part of this program to his memory. But modesty must sometimes be sacrificed to greatness and indeed this is true in the case of Harold DeWitt Smith.

Harold Smith was born in Bayonne, New Jersey, on September 27, 1896. He and his brothers, Victor and John Edgar, grew up in that city in the way of normal American boys. His parents, Edward R. and Caroline Emily Smith, had reason to be proud of his scholarship as well as the sincerity and honesty which characterized his behavior. By the time he was a junior in high school the "Harold Smith Conscience" had become a byword among his schoolmates. At the age of nine he met a certain Miss Helen Tichenor, thanks to the alphabetical seating arrangement in the schoolroom, and their friendship grew as time went on to the point where he surprised her by insisting on being her escort at the Senior Prom. That was in 1915, when he graduated with high honors from the Bayonne High School.

Harold Smith entered Lehigh University in the fall of 1915 and began his studies with interest and vigor. In accord with the times, he received military training in the Lehigh S.A.T.C. unit, and later a commission as second lieutenant of Infantry from the Plattsburg training center. His military service did not include a sojourn in France, for he was stricken with a severe case of influenza which extended for several months beyond the conclusion of hostilities. As soon as health permitted, he returned to Lehigh

* Director of Research, the Textile Foundation and the Textile Research Institute, Inc.

† The title of Dr. Smith's paper was to be "Properties of Woven Fabric as Anticipated from Fiber Properties."

and pursued all his courses with enthusiasm but particularly chemistry, physics, and engineering. His extracurricular activities included lacrosse, Arcadia, and Y.M.C.A. cabinet. He was honored by election to Tau Beta Pi and graduated in 1920 with the degree of Ch. E. In later years the Lehigh Chapter of Sigma Xi conferred membership upon him. In the words of the 1920 Lehigh year book, "Epitome," he was described as "an eminent and respected citizen of this community."

Harold Smith's first job was in the vegetable oils industry but it was not long until he found more challenging work in the field of rubber. It was in an Akron rubber testing laboratory that he was "discovered" by David Scott, who reported to Ashton M. Tenney, then technical director of Wellington Sears and Company, that he had found just the man to operate his testing laboratory. Mr. Tenney brought Harold Smith to Wellington Sears in 1922 and there began a pleasant and mutually stimulating friendship which lasted to the day of Dr. Smith's untimely death in Mexico on February 10, 1947. During the five years which he spent at Wellington Sears in studying the chemical and physical properties of textiles, Harold Smith developed an intense interest in fibers and fabrics. In particular, he was intrigued with the possibilities of various types of rayon which were just coming into wide use. He also met, quite by accident in New York, an attractive young lady by the name of Helen Tichenor. The association, interrupted upon his leaving for college, was immediately renewed and developed into something beyond friendship. In fact, the question of marriage was often discussed but, by this time, Harold Smith knew that his life was to be devoted to textile research and that he must, therefore, acquire advanced training in this field. Miss Tichenor quite agreed with him and probably had something to do with his decision to study abroad. He resigned from Wellington Sears in 1927, at about the same time that A. M. Tenney left to become vice-president of the American Bemberg Corporation.

In his efforts to select an institution where he could go on with his scientific education, Harold Smith consulted his friend, Professor Gilbert Doan of Lehigh University. Doan, himself a graduate of the University of Berlin in Metallurgy, suggested that he consider that institution.

A. M. Tenney had met the famous German cellulose chemist, R. O. Herzog, at a Symposium in Montreal and was enthusiastic in his praise. Hence, it was natural that Harold Smith should be attracted to Dr. Herzog's laboratory at the Kaiser Wilhelm Institut für Faserstoffchemie in Berlin-Dahlem. It must have taken courage for Harold Smith to leave a promising industrial career at the age of thirty to enroll in a German university. However, he knew what he wanted to do and that settled the matter. He spent three years in graduate study under Dr. Herzog, who was then director of the Institut. He showed outstanding ability, both as a student and in the laboratory, where he performed the first creep and relaxation measurements ever made on synthetic fibers. On one occasion he was entrusted with the reading of one of Herzog's important papers at a symposium in Brussels. He also was fortunate in becoming acquainted with the brilliant young scientist, Hermann Mark, who had already contributed much to the literature on cellulose. At that time, Dr. Mark was in charge of the group engaged in x-ray diffraction work and Harold Smith was very interested in these studies. Dr. Mark states that Harold Smith spoke excellent German from the beginning of his study at the Institut and participated actively in all the seminars. In 1930 he received his Ph.D. degree in physical chemistry from the University of Berlin, on the basis of his research at the Kaiser Wilhelm Institut.

At about the same time that Dr. Smith returned to the United States, Mr. Tenney organized A. M. Tenney Associates, and it was in that year—1930—that Dr. Smith joined that company, which became sole sales representative for Tennessee Eastman Corporation. The early history of A. M. Tenney Associates was one of developing acetate rayon yarns and processes. Soon Dr. Smith was placed in charge of sales service and was made treasurer of the firm in 1931. In 1946 he became vice-president and treasurer.

In view of his pressing duties, which involved practical product engineering and development of markets, it is remarkable that Dr. Smith was able to keep firmly abreast of all scientific work in the textile field. Throughout his long career he continued to contribute sound scientific papers. In this work he was aided greatly by Helen Tichenor Smith, whom he married in 1934. With her help, an excellent scientific library and filing system was maintained in their New York apartment.

A survey of Dr. Smith's publications reveals, first of all, an amazing versatility embracing many fields of chemistry and physics. His first two papers [1,

2], which constituted his Ph.D. thesis on work done at the Kaiser Wilhelm Institut für Faserstoffchemie, were published in the *Journal of the Textile Institute* in 1931. The first of these was entitled "Apparatus for the Measurement of Flow and Relaxation of Textile Filaments." Two instruments developed by Dr. Smith are described in this paper, the first a modified Polanyi Tester adapted to flow tests on single filaments, and the second a balance device which was used both for fiber flow and relaxation experiments. Great care in the design of the instruments and interpretation of the results is apparent. It is interesting to note that measurements of flow (creep) and relaxation were made not only at various humidities but at elevated temperatures. The second of these papers, written with R. Eisenshitz, was entitled "The Flow and Relaxation of Rayon Filaments." In this work, experiments were performed with the devices described in the first paper [1], with the object of testing the validity of the Maxwell and Boltzmann concepts of deformation with viscose rayon, acetate rayon, and silk. In brief, it was found that "the Boltzmann after-effect theory provides a useful approximation to the actual behavior of rayon." Certain departures from the Boltzmann theory were evident, however, and it is safe to assume that these observed discrepancies stimulated Dr. Smith's interest in encouraging later extensive researches in this field, such as those of Leaderman * and Eyring †.

Many of Dr. Smith's later publications and addresses were valuable in the expository sense rather than as original scientific contributions. Interested as he was in expanding the uses of acetate rayon, it is not surprising that he often spoke and wrote on that subject [6, 8, 10, 12, 13, 15, 17, 22]. Nevertheless, his approach was always that of the scientist and engineer, not that of the salesman. His knowledge of, and experience with, acetate rayon were so broad that his writings might well be compiled to form a textbook on the subject. His unusual ability to describe phenomena in simple, concise, but accurate terms is evident in several general papers [3, 4, 7, 9, 11, 14, 16] which have had a definite function in the growth of textile research in this country. Dr. Smith's greatest contribution to the scientific literature of textiles was his Marburg Lecture read before the Forty-Seventh Annual Meeting of the American Society for Testing Materials in 1944 [18]. The paper, reprinted by the A.S.T.M., is entitled "Textile Fibers—An Engineering Approach to their Properties and Uses." This paper is certainly one of the classics in the textile field, not only in the historical and philosophical aspects, but because it embodies constructive original scientific thought which challenges the best efforts of scientists in the field.

The contributions of Dr. Smith to the war effort during World War II will probably never be thoroughly understood nor adequately estimated. He served on the Advisory Board, Research and Development Branch, Office of The Quartermaster General, and was Chairman of the Technical Subcommittee on Synthetic Textiles. Dr. Smith was a kindly person who hated war and the human suffering which it caused, yet he served with enthusiasm and zeal even beyond his physical capacity. After two years of commuting between New York and Washington, upon his doctor's stern advice he asked to be relieved of his war duties. However, shortly thereafter a very secret and important development became necessary and Dr. Smith was again called to Washington by The Quartermaster General. In the subsequent period, he unselfishly worked long hours, seven days each week, in spite of his indifferent health, and accomplished the task before him with such brilliance that the results of his work will probably be influential in the advanced design of Army uniforms for many years.

Dr. Smith received many honors in the course of his life and was a member of many scientific societies. Among these were a Fellowship in the Textile Institute (England) since 1932 and an honorary Life Membership in that organization since 1938. He was a member of Sigma Xi, an honorary member of the American Association of Textile Technologists, a member of the board of directors of the Textile Research Institute, Inc., a trustee of the Textile Museum of the District of Columbia, Chairman of the Scientific Advisory Committee of the Textile Foundation, and a member of the Chemists Club, the American Chemical Society, the American Association for the Advancement of Science, the American Association of Textile Chemists and Colorists, the Society of Chemical Industry (England), the Faraday Society, the Royal Society for the Encouragement of Arts, Manufactures and Commerce, and the Society of Dyers and Colourists (England). But he did not accept membership in any society without feeling the

* Herbert Leaderman, "Elastic and Creep Properties of Filamentous Materials and Other High Polymers," The Textile Foundation, 1943.

† The Mechanical Properties of Textiles, Henry Eyring and coworkers, TEXTILE RESEARCH JOURNAL **15**, 295, 451 (1945); **16**, 13, 53, 124, 201, 329, 335, 378, 382, 635 (1946).

obligation to contribute to its program. This he did, at one time or another, in all of the societies in which he held membership. In particular, it seems appropriate for me to mention his major contributions to the work of the Textile Research Institute and the Textile Foundation. First of all, Dr. Smith was firmly convinced that the American textile industry stood to benefit greatly by reasearch, both pure and applied. Thus, as one of the twenty American members of the British Textile Institute, he participated in 1926 in the formation of the Textile Research Council, a nonprofit corporation of the State of New York. The underlying thesis of the Textile Research Council was that the textile industry itself should promote research on an industry-wide basis. In 1930, the Textile Research Council became the United States Institute for Textile Research, and in 1940 the name was simplified to Textile Research Institute. Throughout its history, Dr. Smith worked unstintingly for its welfare. He served as unpaid president of the Institute in the year 1945 and devoted several months of his busy life to enlarging its membership and establishing a sound organization. At the time of his death, Dr. Smith was a director of the Institute and his sage counsel at Directors' Meetings is sadly missed. He played a salient role in establishing the present laboratory in Princeton and in setting up the engineering research program which involves four principal projects: moisture equilibrium determinations, the elements of warp sizing, fiber damage studies, and infrared drying. Dr. Smith was a very enthusiastic supporter of the Institute policy of setting up graduate fellowships in chemistry and engineering. Thirteen Textile Research Institute Fellows are now enrolled in the Graduate School of Princeton University. Their thesis research is done in the Institute laboratories in the general field of textiles; otherwise, they are regular graduate students of Princeton University. Another TRI Fellow has been appointed at the University of Utah to work under Professor Henry Eyring, and eventually fellowships will be established at several other universities. Dr. Smith was intensely interested in the progress and welfare of the Fellows and enjoyed discussing their individual problems with them on his visits to Princeton.

Dr. Smith also participated actively in the Textile Foundation program and served for many years on its Research Advisory Committee. At the time of his death, he was Chairman of that Committee. Notwithstanding his long absence from actual laboratory research, he delighted in discussing in detail the fundamental research studies under way at the Princeton laboratories. His ability to grasp new complex theories and quickly probe to the heart of each problem was truly amazing and stimulating. He was actively interested in all four fundamental research projects of the Foundation group and had much to do with their selection. They may be classified as studies of (1) mechanical properties of fibers, (2) sorption-swelling phenomena, (3) relaxation-birefringence effects, and (4) organic chemical studies of cellulose. It is seen that these four projects add up to a tetrapronged attack aimed at a better knowledge of fiber structure. Dr. Smith often remarked that his hobby was to learn all he could about textiles; thus, the Foundation research program might be considered an expression of both his life work and his hobby. His absence from the pleasant and helpful committee meetings at Princeton is sadly regretted by his associates and, I assure you, by the research director, who had come to depend greatly on his advice and encouragement.

A brief glimpse at the last years of Dr. Smith's life serves to bring out his human characteristics. In 1940 he had purchased a beautiful farm in Connecticut, which became a sort of retreat from the cares of his business in New York. There he could indulge his hobby of photography, an art at which he excelled, as he strolled along the pleasant lanes dividing the fields, each of which he had given an appropriate, original name. It was there that he wrote the Marburg Lecture. Although he had dedicated the farm to Peace, that did not mean inactivity to Harold Smith. Peace, for him, was the opportunity to work diligently in his chosen field, encourage the research of others, and enjoy the company of his many friends and associates. While he had given generously of his best efforts to his country in time of war, he longed to resume the role of scientist in a world at peace. Having enjoyed a life of productivity and service, he asked only to be allowed to continue, but the request was not granted.

Bibliography of Works

By Harold DeWitt Smith

1. Apparatus for the Measurement of Flow and Relaxation of Textile Filaments, *J. Text. Inst.* **22**, T158 (1931).
2. The Flow and Relaxation of Rayon Filaments (with R. Eisenschitz), *J. Text. Inst.* **22**, T170 (1931).

3. Some Aspects of the Structure and Properties of the Rayons. Preprint of a paper presented at the 35th Annual Meeting of the American Society for Testing Materials, June, 1932.
4. The Rayon Industry—A Quarter Century of Progress, *Am. Dyestuff Reptr.* **22**, 322 (1933).
5. The Activities of the United States Institute for Textile Research, *Am. Dyestuff Reptr.* **24**, 513 (1935).
6. Cellulose Acetate Process. A discussion prepared for the Brooklyn Museum, November 16, 1936.
7. The Structure of Cellulose, TEXTILE RESEARCH **7**, 453 (1937).
8. Acetate Staple, *Textile Age* **1**, 45 (October, 1937).
9. Rayon Fabric Construction from the Manufacturer's Viewpoint. Address given at the Annual Convention of the National Association of Dyers and Cleaners, Chicago, January, 1938.
10. Some Properties of Cellulose Acetate Rayon Fibers of Interest to Dyers and Finishers, *Am. Dyestuff Reptr.* **27**, 213 (1938).
11. Rayon Developments—Trends in Man-Made Fiber Production, *Can. Text. J.* **56**, 32 (May 26, 1939).
12. Teca—Its Properties and Utilization, *J. Text. Inst.* **30**, T153 (1939).
13. The Dyeing and Finishing of Fabrics Containing Rayon Staple Fibers, *Rayon Text. Mo.* **21**, 82 (January, 1940); **21**, 69 (February, 1940).
14. Rayon Staple Fibers for the Wool Industry. Address presented at the "Symposium on Synthetics," National Association of Wool Manufacturers, Boston, April 4, 1940.
15. Cellulose Acetate Rayons, Types, Properties, and Uses, *Ind. Eng. Chem.* **32**, 1555 (1940).
16. Recent Developments in Synthetic Fibers and Fabrics. Address delivered at opening session of The Rayon Institute of the Textile School of North Carolina State College, Raleigh, May 5, 1941.
17. Acetate Rayon, *Am. Dyestuff Reptr.* **33**, P124 (1944).
18. Textile Fibers, An Engineering Approach to Their Properties and Utilization. Reprint from *Proceedings of the A. S. T. M.* **44** (1944).
19. Comments on the Program of Research, in "Proceedings" of the Conference on Quartermaster Textile Research, Washington, D. C., October 25, 1945. Pages 60 and 61 of booklet published by Textile Research Institute, Inc., New York, 1945.
20. Annual Report of the President, Textile Research Institute, Inc. Supplement to TEXTILE RESEARCH JOURNAL **15**, 1 (December, 1945).
21. General Education in Textiles. Address delivered at New York Dinner of Alumni Association of the Philadelphia Textile Institute, December 14, 1945. Booklet published by the Philadelphia Textile Institute Foundation, Philadelphia.
22. Acetate Rayon, *Am. Dyestuff Reptr.* **35**, 71 (1946).

Solution of the Problem of Producing Uniform Abrasion and Its Application to the Testing of Textiles*

Herbert F. Schiefer †

Abstract

A general mathematical solution to the problem of producing uniform abrasion over a plane area of a specimen from every azimuthal direction was worked out. This solution requires that the abradant and the specimen rotate in the same direction and with the same angular velocity. The specimen may revolve about the center of the abradant with any angular velocity in the same direction as or in the opposite direction from its direction of rotation. The specimen must not extend beyond the boundary of the abradant. Simple revolution of abradant about specimen and of specimen about abradant without rotation of either are special solutions. The special solution in which the specimen does not revolve about the center of the abradant is the simplest one from mechanical considerations. A machine based upon this special solution is described and preliminary results obtained with it are discussed.

I. Introduction

Resistance to abrasion is one of the factors which affect the serviceability of many organic and inorganic products, such as textiles, rubber, plastics, leather, linoleum, ceramics, mastic tile, concrete, stone, wood, and metals. An analysis of the problem of measuring the resistance to abrasion shows clearly that it can be resolved into three major phases—namely, (1) the design and development of an abrasion machine which will abrade a plane area of a specimen uniformly over the entire area and from every direction in its plane; (2) the design and development of an abradant which remains constant not only during a test but also between different tests; and (3) the development of a quantitative method for the evaluation of the amount of abrasion. Research has been actively executed on all three phases in the Textiles Section of the National Bureau of Standards, as part of the broad and long-term fundamental program of research on abrasion sponsored and supported by the Office of The Quartermaster General, War Department.‡ A complete mathematical solution for the first phase has been worked out. This solution is presented in this paper and a machine based upon a special case of the general solution is described. The solutions to the second and third phases depend necessarily to some degree upon the type and nature of the material being tested. These two phases have also received a great deal of attention and considerable progress has already been made toward finding their solutions for testing textiles.

A great many abrasion-testing machines have been developed [3, 9]. A review of the literature indicates that in only one case is the relative motion between the specimen and the abradant the same for the whole area of the specimen which is abraded, and in no case is it the same from every direction of the abraded surface. It is not possible, therefore, to attribute unequal wear to a structural difference in the specimen, or "form factor."

In an attempt to approximate the conditions which produce more uniform abrasion, machines with complicated mechanisms have been developed. Haven [4] designed a special cam to produce uniform linear velocity over a major portion of the stroke in a translatory reciprocation. The acceleration and deceleration are confined to $1\frac{1}{2}$ inches at each end of the reciprocation. Repenning [9] developed a machine in which the rotary reciprocation of the specimen was of a different period from that of the translatory reciprocation of the abradant. The relative motion between the specimen and the

* Presented at the February, 1947, meeting of The Fiber Society, New Orleans, Louisiana. This paper is being published also in the July issue of the *Journal of Research, National Bureau of Standards*.

† Senior Physicist, National Bureau of Standards, Washington, D. C.

‡ Permission to publish this paper was granted by the Office of The Quartermaster General.

abradant is a variable figure eight or Lissajous figure. Martindale [7] developed a machine in which the specimen is given two perpendicular translatory reciprocations of different periods. The motions relative to a stationary abradant correspond to variable Lissajous figures. In the Shawmut wear-testing machine [8] special cams move the specimen in two perpendicular directions according to a specific pattern while a rotating abradant is periodically lifted and dropped. Gavan, Eby, and Schrader [2] described a new sandpaper abrasion tester in which the specimen is abraded uniformly unidirectionally. In their machine, 8 specimens are mounted on an endless conveyor in such a manner that in each revolution the specimens move over the sandpaper abradant. The sandpaper moves continuously in the opposite direction so that new abrasive paper is constantly supplied as the abradant, a feature used earlier by Sigler and Holt [10] and also by Larose [6].

II. Problem

The problem which is presented for solution by the first phase is to find the type of motion of the abradant and of the specimen and the conditions for these motions such that a plane area of the specimen is abraded uniformly over its entire area and from every direction in its plane. The problem will be solved if the following two conditions can be satisfied:

1. The instantaneous relative velocity between the abradant and the specimen is constant in magnitude and direction for every point of the abraded area, schematically shown in A of Figure 1.

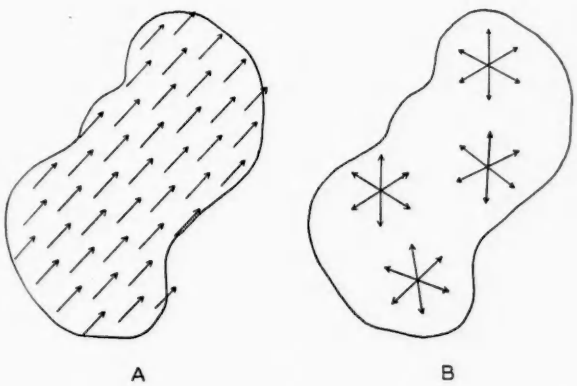


FIG. 1. *Schematic diagram showing uniform unidirectional abrasion,* A, *and uniform abrasion from every azimuthal direction,* B.

2. The instantaneous relative velocity between the abradant and the specimen at any point of this area is constant in magnitude but changes in direction relative to the specimen from instant to instant in a continuous and uniform manner, schematically shown in B of Figure 1.

These conditions simply imply that every point is abraded equally from every azimuthal direction and that this process is repeated over and over again until the test is terminated. It is assumed that the abradant is uniform and remains constant.

III. Solution

1. Discussion

It is apparent that motions of simple translation of the abradant and of the specimen, such as are used by Gaven, Eby, and Schrader [2], meet the first but not the second requirement of the problem. Uniform unidirectional abrasion obtained with their machine is no doubt sufficient for testing a number of materials for such special uses where all the wear is in one direction. The second requirement could be approximated by rotating the specimen through a small angle after each contact with the abradant. Motions of reciprocation, either of translation, rotation, or combinations of translation and rotation, do not meet the conditions of the problem and must be excluded since the relative velocity between the specimen and the abradant varies greatly with time. If the problem has a general solution, then the motions of the abradant and the specimen must consist of rotations and revolutions. From the conditions of the problem it follows that the area to be abraded must at all times be in contact with the abradant. From these remarks it suffices, for a general solution, to consider a large plane abradant, which rotates about its perpendicular axis, and a smaller plane specimen, which simultaneously revolves in the plane of the abradant about the axis of the abradant and rotates in the same plane about its own perpendicular axis in such a way that it is always completely contained within the boundary of the abradant. The abradant is represented schematically in A of Figure 2, and the specimen is represented schematically in B of Figure 2.

2. Rotation of Abradant

Let $P_a(X_0, Y_0)$ in A of Figure 2 be any point of the abradant defined with respect to the XY coordinate axes by $X_0 = R \sin \alpha_0$ and $Y_0 = R \cos \alpha_0$, when $t = 0$. The point P_a rotates about the center

O with a constant angular velocity W. The position of this point at time t is $P_a(X_a, Y_a)$ and is given by the simultaneous equation (1).

$$\left.\begin{aligned} X_a &= R \sin \alpha \\ Y_a &= R \cos \alpha \\ \alpha &= \alpha_0 + Wt \end{aligned}\right\} \tag{1}$$

The X and Y components of the velocity of the point $P_a(X_a, Y_a)$ at any time t, and the magnitude and slope of the resultant velocity, are given by equation (2).

$$\left.\begin{aligned} V_{X_a} &= \frac{dX_a}{dt} = WY_a \\ V_{Y_a} &= \frac{dY_a}{dt} = -WX_a \\ |V_a| &= W\sqrt{X_a^2 + Y_a^2} = W|R| \\ m_{V_a} &= -\frac{X_a}{Y_a} \end{aligned}\right\} \tag{2}$$

The slope m_{V_a} is the negative reciprocal of the slope of the radius vector R, which is $m_R = Y_a/X_a$. The velocity vector V_a is thus at right angles to the radius vector R.

3. Rotation of Specimen

Let $p_s(x_0, y_0)$ be any point of the specimen defined with respect to the xy coordinate axes by $x_0 = r \sin \beta_0$ and $y_0 = r \cos \beta_0$, when $t = 0$. The point p_s rotates about the center C with a constant angular velocity w. The position of this point at time t is $p_s(x_s, y_s)$ and is given by the simultaneous equation (3).

$$\left.\begin{aligned} x_s &= r \sin \beta \\ y_s &= r \cos \beta \\ \beta &= \beta_0 + wt \end{aligned}\right\} \tag{3}$$

The x and y components of the velocity of the point $p_s(x_s, y_s)$ at any time t and the magnitude and slope of the resultant velocity are given by equation (4).

$$\left.\begin{aligned} v_{x_s} &= wy_s \\ v_{y_s} &= -wx_s \\ |v_s| &= w\sqrt{x_s^2 + y_s^2} = w|r| \\ m_v &= -\frac{x_s}{y_s} \end{aligned}\right\} \tag{4}$$

The slope m_{v_s} is the negative reciprocal of the slope of the radius vector r, which is $m_r = y_s/x_s$. The velocity vector v_s is thus at right angles to the radius vector r.

4. Revolution of Specimen

Let $P_c(X_0, Y_0)$ be the position of the center of rotation C of the specimen defined with respect to the XY coordinate axes by $X_0 = R_c \sin \gamma_0$ and $Y_0 = R_c \cos \gamma_0$, when $t = 0$, which revolves about the center O with a constant angular velocity Ω. The position of this point at time t is $P_c(X_c, Y_c)$ and is given by the simultaneous equation (5).

$$\left.\begin{aligned} X_c &= R_c \sin \gamma \\ Y_c &= R_c \cos \gamma \\ \gamma &= \gamma_c + \Omega t \end{aligned}\right\} \tag{5}$$

The X and Y components of the velocity of the point $P_c(X_c, Y_c)$ at any time t and the magnitude and slope of the velocity are given by equation (6).

$$\left.\begin{aligned} v_{X_c} &= \Omega Y_c \\ v_{Y_c} &= -\Omega X_c \\ |v_c| &= \Omega\sqrt{X_c^2 + Y_c^2} = \Omega|R_c| \\ m_{v_c} &= -\frac{X_c}{Y_c} \end{aligned}\right\} \tag{6}$$

The slope m_{v_c} is the negative reciprocal of the slope of the radius vector R_c, which is $m_{R_c} = Y_c/X_c$. The velocity vector v_c is thus at right angles to the radius vector R_c.

5. Rotation and Revolution of Specimen

The position of the point $p_s(x_s, y_s)$ referred to the XY coordinate axes is $P_s(X_s, Y_s)$, where $X_s = X_c + x_s$ and $Y_s = Y_c + y_s$. From equations (4) and (6) it follows that the X and Y components of the velocity of the point $P_s(X_s, Y_s)$ at any time t and the magnitude and slope of the resultant velocity are given by equation (7).

$$\left.\begin{aligned} V_{X_s} &= \Omega Y_c + wy_s \\ V_{Y_s} &= -(\Omega X_c + wx_s) \\ |V_s| &= \sqrt{\Omega^2(X_c^2 + Y_c^2) + w^2(x_s^2 + y_s^2) + 2w\Omega(x_sX_c + y_sY_c)} \\ m_{V_s} &= -\frac{\Omega X_c + wx_s}{\Omega Y_c + wy_s} \end{aligned}\right\} \tag{7}$$

6. Relative Velocity Between Specimen and Abradant

If the abradant A of Figure 2 and the specimen B of Figure 2 are superimposed and the values of $|R|$, $|R_c|$, $|r|$, α_0, β_0, and γ_0 are so chosen that at any time t the points $P_a(X_a, Y_a)$ and $P_s(X_s, Y_s)$ coincide at the point $P(X, Y)$ in A of Figure 3—that is, $X = X_a = X_s$ and $Y = Y_a = Y_s$—then the relative velocity between the abradant and the speci-

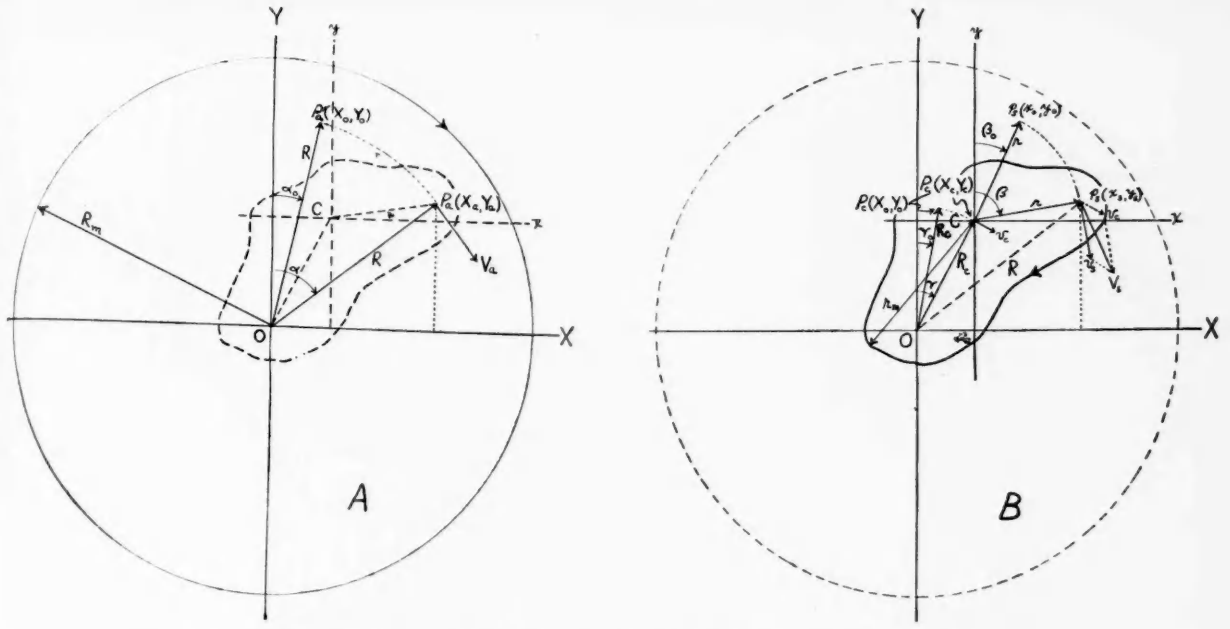


FIG. 2. *Schematic diagram illustrating motion of abradant,* A, *and of specimen,* B.

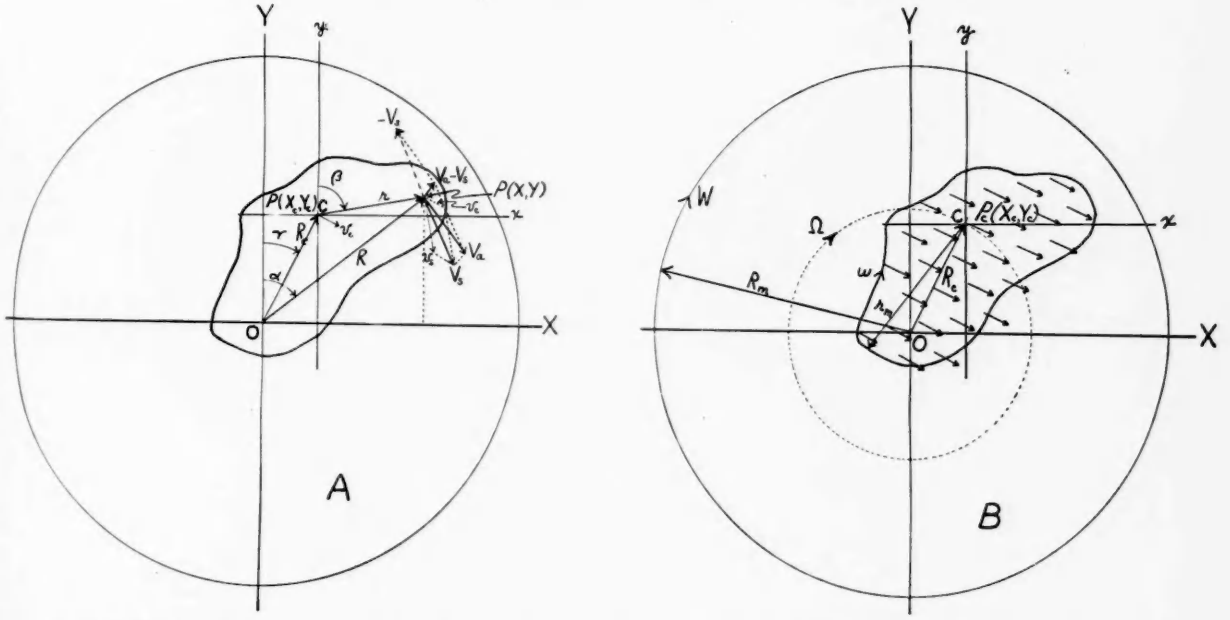


FIG. 3. *Schematic diagram showing relative velocity between abradant and specimen, A, and uniform instantaneous relative velocity, B.*

men at the point $P(X, Y)$, which is any point common to both the abradant and the specimen at any time t, is given by the vector difference between the velocities for the abradant and for the specimen at the point $P(X, Y)$. The X and Y components of the relative velocity at the point $P(X, Y)$ at any time t and the magnitude and slope of the resultant relative velocity are given by equation (8).

$$\left.\begin{aligned} V_{X_a}-V_{X_s} &= (W-w)\,Y+(w-\Omega)\,Y_c \\ V_{Y_a}-V_{Y_s} &= -(W-w)X-(w-\Omega)X_c \\ |V_a-V_s| &= \sqrt{\begin{matrix}(W-w)^2(X^2+Y^2)+(w-\Omega)^2 \\ \times(X_c^2+Y_c^2)+2(W-w) \\ \times(w-\Omega)(X_cX+Y_cY)\end{matrix}} \\ m_{(V_a-V_s)} &= -\frac{(W-w)X+(w-\Omega)X_c}{(W-w)\,Y+(w-\Omega)\,Y_c} \end{aligned}\right\} \quad (8)$$

Since W, w, and Ω are constants which may have any real values, we may write $W = nw$ and $\Omega = Nw$, where n and N are any real numbers. Substituting these values for W and Ω in equation (8) results in equation (9).

$$\left.\begin{aligned} V_{X_a} - V_{X_s} &= [(n-1)Y + (1-N)Y_c]w \\ V_{Y_a} - V_{Y_s} &= -[(n-1)X + (1-N)X_c]w \\ |V_a - V_s| &= w\sqrt{\begin{matrix}(n-1)^2(X^2+Y^2)+(1-N)^2 \\ \times(X_c^2+Y_c^2)+2(n-1) \\ \times(1-N)(X_cX+Y_cY)\end{matrix}} \\ m_{(V_a-V_s)} &= -\frac{(n-1)X+(1-N)X_c}{(n-1)Y+(1-N)Y_c} \end{aligned}\right\} \quad (9)$$

7. General Solution

The conditions of the problem, namely, uniform abrasion over the entire abraded area of the specimen at any time t, require that both $V_{X_a} - V_{X_s}$ and $V_{Y_a} - V_{Y_s}$ are constant for every point $P(X, Y)$ of the abraded area. It follows, therefore, that the identities given by equation (10),

$$\left.\begin{aligned} (n-1)Y + (1-N)Y_c &\equiv k_1/w = \text{constant}, \\ (n-1)X + (1-N)X_c &\equiv k_2/w = \text{constant}, \end{aligned}\right\} \quad (10)$$

must be satisfied, where k_1 and k_2 are constants. From these identities it follows that $(n-1)$ must equal zero—that is, $n = 1$ and therefore $W = w$. In other words, for the general solution of the problem for uniform abrasion over the entire area of the specimen, both the abradant and the specimen must rotate in the same direction and with the same angular velocity. No restrictions whatsoever are imposed upon the values of N, X_c, Y_c, and w. They can be varied at will providing the relationship $|r_m| \leq |R_m| - |R_c|$ is satisfied. This relationship merely implies that the specimen is always in contact with the abradant. The specimen may have any shape and it may revolve about the center of rotation of the abradant with any angular velocity in the same direction as or in the opposite direction from the direction of rotation of the abradant. The specimen may be placed in any position relative to the abradant providing the distance between the two centers of rotation $|R_c|$ satisfies the expression $|R_c| \leq |R_m| - |r_m|$.

In this general solution of the problem (that is, when $n = 1$, $W = w$, and $\Omega = Nw$) equation (9) reduces to equation (11).

$$\left.\begin{aligned} V_{X_a} - V_{X_s} &= (1-N)wY_c \\ V_{Y_a} - V_{Y_s} &= -(1-N)wX_c \\ |V_a - V_s| &= (1-N)w\sqrt{X_c^2 + Y_c^2} \\ &= (1-N)w|R_c| \\ m_{(V_a-V_s)} &= -\frac{X_c}{Y_c} \end{aligned}\right\} \quad (11)$$

The slope of the relative velocity vector $m_{(V_a-V_s)}$ is the negative reciprocal of the slope of the radius vector R_c, which is $m_{R_c} = Y_c/X_c$. The relative velocity vector, $V_a - V_s$, is therefore always at right angles to the radius vector R_c, which joins the centers of rotation of the abradant and of the specimen. This condition is shown schematically in B of Figure 3 at the time t.

The slope angle of R_c changes 360 degrees in each revolution of point C about O and the slope angle of r also changes 360 degrees in each rotation of the specimen about C. Therefore, the direction of the relative velocity vector at every point of the specimen changes through 360 degrees with respect to the specimen for every change of 360 degrees in the angular difference $|\beta - \gamma|$. But $|\beta - \gamma| = |\beta_0 - \gamma_0| + |w - \Omega|t = |\beta_0 - \gamma_0| + |1 - N|wt$. From this expression it can be seen that the relative velocity vector at every point of the specimen changes once through 360 degrees in $1/|1 - N|$ rotations of the specimen. This condition is shown schematically in Figure 4, where any small element

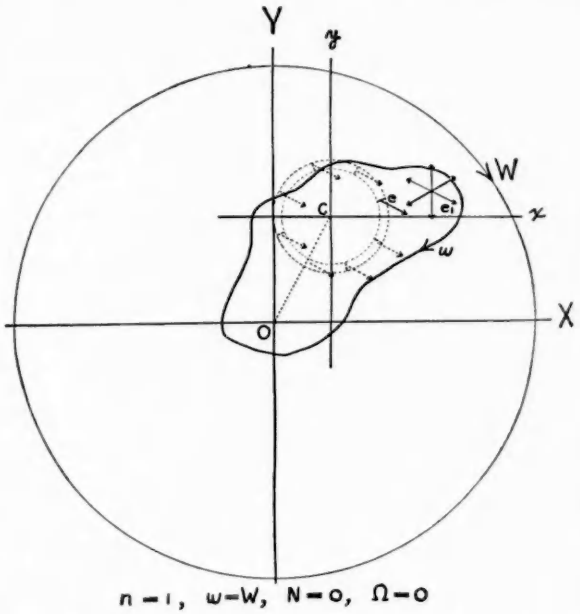


FIG. 4. *Schematic diagram showing attainment of uniform abrasion from every azimuthal direction for a special solution of problem.*

of the specimen, e, assumes all of the different indicated positions in one rotation for the special case when $N = 0$—that is, for the case where the specimen does not revolve about the center O. It is clear that the element e is abraded equally from all directions in one rotation, as indicated on the element e_1. Obviously, if $N > 2$ or if the direction of revolution is opposite to the direction of rotation—that is, $N < 0$—then the relative velocity vector at every point of the specimen will change through 360 degrees more frequently than for the special case when $N = 0$ and for $0 < N \leq 2$.

A complete general solution of the problem of uniform abrasion from every azimuthal direction has thus been obtained. It requires that the abradant and the specimen rotate about their respective centers with the same angular velocity w. The specimen may be revolved about the center of the abradant with any angular velocity Nw, where N is any real number, including 0.

It can be seen from the expression of the relative velocity given by $|V_a - V_s| = (1 - N)w|R_c|$ and from the slope of the relative velocity vector given by $m_{(Va-Vs)} = -(X_c/Y_c)$ that the relative motion between the abradant and the specimen for the general solution of the problem is equivalent to a mere revolution of the specimen about the center of the abradant, or of the abradant about the center of the specimen, with an angular velocity equal to $(1 - N)w$. This equivalence can be shown in another way by referring the motions to a system of coordinate axes which rotate about the center of the abradant with an angular velocity $w = W$. The abradant is at rest with respect to this system of rotating axes and the specimen does not rotate but merely revolves with the angular velocity $(1 - N)w$. Similarly, if the motions are referred to a system of coordinate axes which rotate about the center of the specimen with an angular velocity $w = W$, then the specimen is at rest with respect to this system of rotating axes and the abradant does not rotate but merely revolves with the angular velocity $(1 - N)w$. Thus uniform abrasion from every direction can be obtained by a simple motion of revolution of either the abradant or the specimen.

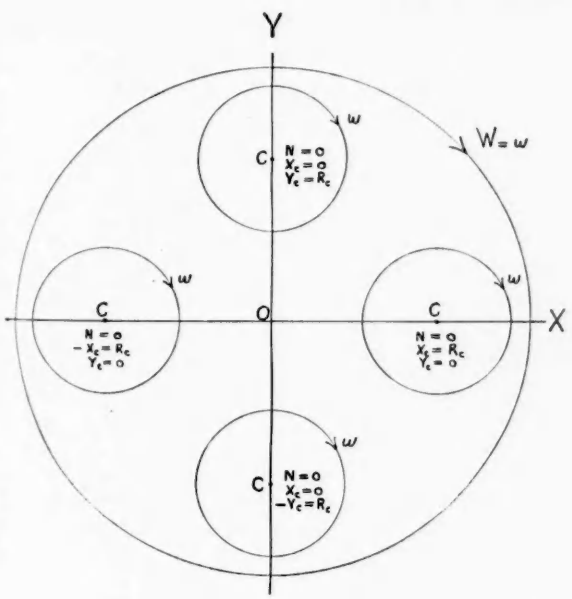


FIG. 5. *Schematic diagram showing four special solutions of simplest type,* N = 0.

8. *Special Solution*

The simplest motion, however, from mechanical consideration is the special solution when $N = 0$. This solution corresponds to one where the specimen does not revolve about the center of the abradant—that is, the center of the specimen is at rest relative to the center of the abradant. The motions of abradant and of specimen consist merely of rotation in the same direction and with the same angular velocity.* This arrangement is shown schematically in Figure 5 for testing 4 specimens simultaneously. In this arrangement each specimen is abraded against the same area of the abradant in each rotation of the specimen and abradant.

9. *Degenerate Solutions*

The special solution when $N = 1$ corresponds to one where the direction and angular velocity of revolution of the specimen about the center of the abradant are the same as the direction and angular

* In the preparation of this paper it was discovered that Colonel Charles Dévé [1] had found experimentally, in polishing plane surfaces of glass, that uniform wear is obtained if the glass and the abradant rotate in the same direction and with the same angular velocity, providing that no part of the glass surface extends beyond the boundary of the abradant. He showed that if a small glass disc is placed off center on a rotating abradant and is held in a fixed position at its center by a pin which permits free rotation of the glass disc about this pin, then the glass disc commences to rotate slowly in the same direction as the abradant and eventually attains the same angular velocity as the abradant. Intuitive reasoning led him to conclude that the system of free rotation on a rotating abradant is a system of uniform wear providing the glass disc does not extend beyond the boundary of the abradant.

Kessler [5] developed an abrasion machine for stone in which the abradant and the specimen were positively rotated in the same direction but at different angular velocities. If he had made the angular velocities equal, then he would have had a machine conforming to the special solution $N = 0$ of the general solution presented in this paper.

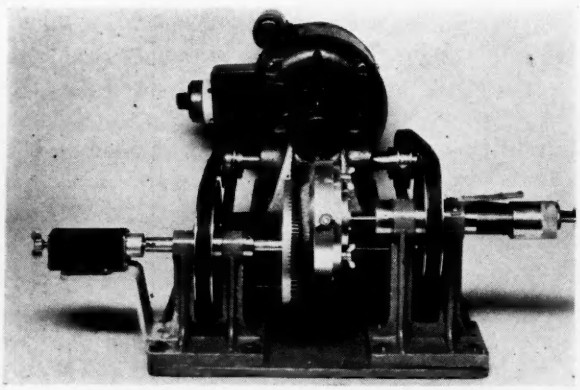


FIG. 6. *Abrasion machine based upon special solution of simplest type,* N = 0.

velocity of rotation of both the abradant and the specimen. For this case the relative velocity between the specimen and the abradant is zero for every point of the specimen. In other words the specimen is at rest relative to the abradant and no abrasion is produced. This special case is a degenerate solution of the problem for uniform abrasion—namely, no abrasion.

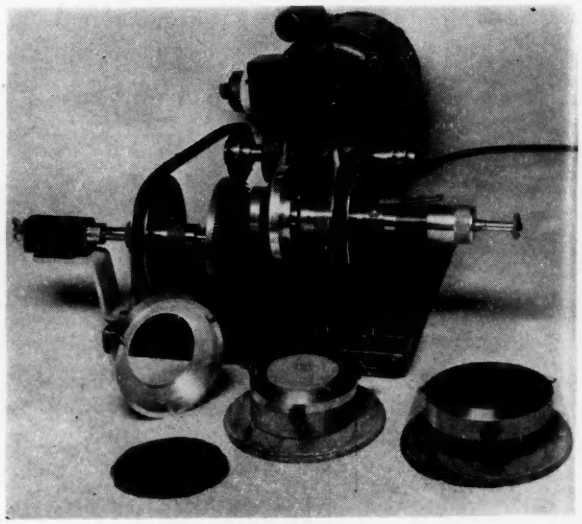
The special solution when $X_e = 0$ and $Y_e = 0$ corresponds to one where the abradant and the specimen are coaxial and the motion of revolution of the specimen vanishes since $|R_e| = 0$. Since the abradant and the specimen rotate in the same direction and with the same angular velocity, the relative velocity is again zero for every point of the specimen—that is, the specimen is at rest relative to the abradant and no abrasion is produced. This special case is another degenerate solution of the problem for uniform abrasion—namely, no abrasion.

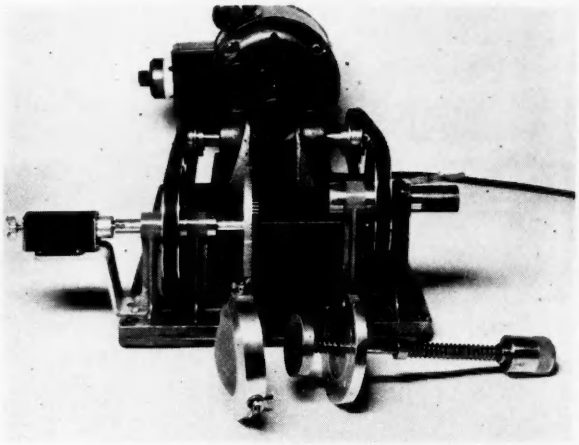
The special solution when $w = 0$ corresponds to one in which both the abradant and the specimen are at rest and no abrasion is produced. It is still another degenerate solution of the problem for uniform abrasion—namely, no abrasion.

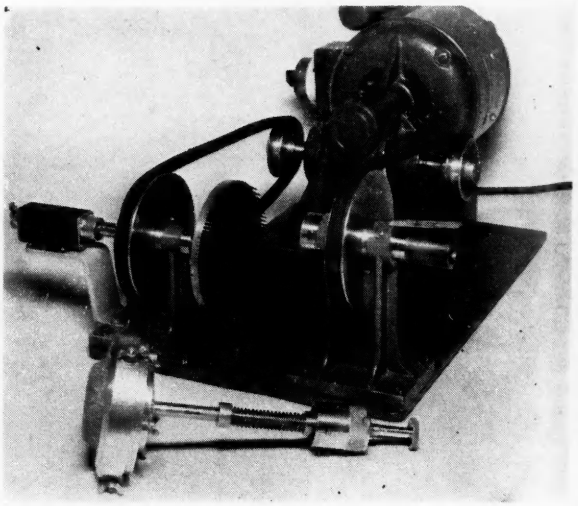
IV. Abrasion Machine Based on Special Solution $N = 0$

1. Description

An abrasion machine based upon the special solution when $N = 0$—that is, when the specimen does not revolve about the center of the abradant—is shown in Figure 6. It consists of a motor speed reducer with a pulley attached to each end of a double shaft. The pulley at the left rotates the abradant and the pulley at the right rotates the specimen. The direction and speed of rotation are







FIGS. 7, 8, and 9. *Abrasion machine showing mounting of the specimen and springs for applying tension and pressure.* (FIG. 7, *top;* 8, *center;* 9, *bottom.*)

the same for the abradant and the specimen. Several additional pulleys were provided so that tests could also be made with the speed of the abradant greater or less than that of the specimen.

The specimen can be mounted in a number of ways. The different steps of one method are shown in the foreground of Figures 7, 8, and 9. In Figure 7 a circular specimen and two parts of a clamp are shown in the left foreground. One part of the clamp is shown in place on a wooden holder with a slightly curved wooden hub projecting upward through the central opening. The circular specimen is placed over this hub and the second part of the clamp is securely fastened to the first part, as shown in the right foreground of Figure 7. When the clamp is removed from the wooden holder, an outer annular ring, about 1 inch in width, of the specimen is securely held by the clamp and the central portion is lax and assumes a more or less spherical shape, as shown in the foreground of Figure 8. The clamp is then attached to the large disc shown in the right foreground. In doing this the small disc is forced against the lax specimen by the small spring which is compressed to a given amount. The lax specimen is thus placed under a given tension which is distributed over its entire periphery, as shown in the foreground of Figure 9. When the shaft to which the specimen and clamp are attached is in place, as shown in Figure 6, then the spring, shown in Figure 9, can be compressed a known amount by the micrometer screw at the right end of the spring. The force of compression presses the specimen against the abradant. Both the tension in mounting the specimen and the force of compression can be controlled and varied in magnitude. If the specimen stretches during a test, the stretch is automatically taken up by the tensioning device. Similarly, as the thickness of the specimen decreases during the test the change of thickness is automatically taken up by the pressure unit. The slight decreases in tension and pressure from these automatic adjustments appear to be negligible. The change in the latter can be compensated for by turning the micrometer head an amount equal to the decrease in thickness of the specimen.

2. Abradant

Any of the usual abradants used in abrasion testing for textiles can be used with the machine. Most of these, however, change considerably during a test. In the development of an abradant which remained constant, many different abradants were considered. The abradant shown in Figure 9 was finally decided upon as representing the type most likely to remain constant. It consists of a disc $4\frac{1}{2}$ inches in diameter in one face of which are inserted a series of parallel strips of clock springs, spaced $\frac{1}{8}$ inch apart, each strip being 0.025 inch thick and protruding $\frac{1}{4}$ inch. The edges of these springs were ground and lapped to a plane surface, which constitutes the abradant for textile materials. From the tests made to date this abradant appears to remain constant. Obviously, it is not entirely uniform over its area.

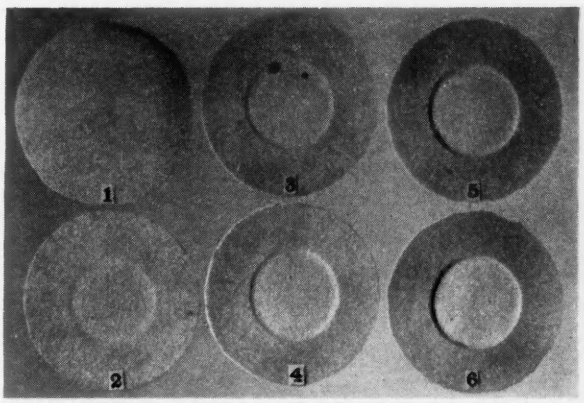


FIG. 10. *Felt specimens showing abrasion produced by the machine in increments of 5,000 rotations of the specimen.*

3. Results of Preliminary Tests

Exploratory tests have been made with the abrasion machine on a great variety of different textile materials. By appropriate choice of total pressure between the specimen and the abradant it was found that the materials tested could be abraded to destruction in a reasonable time. Tests were also made by rotating the specimen at a much higher or lower angular velocity than that of the abradant. For such tests the abrasion was not uniform over the abraded area, confirming the prediction of the mathematical solution. Uniform abrasion was obtained when the two angular velocities were equal. The rate of abrasion increased with the angular velocity.

A series of different felts were tested under a variety of different testing conditions. The specimens shown in Figure 10 are of one felt. Specimen No. 1 is an untested specimen. Specimens Nos. 2, 3, 4, 5, and 6 were tested for 5,000, 10,000, 15,000, 20,000, and 25,000 rotations, respectively. They show that the abrasion over a circular area 2 inches

in diameter is uniform. The decrease in thickness with the number of rotations appears to be a promising method for a quantitative index of abrasion for felts.

The fact that the abradant was not uniform over its entire area did not affect the uniformity of the abrasion. This result was not expected. A close check on the speeds indicated that, owing to a slight difference in the belt drive, the abradant made one more rotation than the specimen in every 240 rotations, or 1 minute. The effect of nonuniformity of the abradant was automatically eliminated by this slight difference in speed. As a matter of fact, since abradants are as a rule nonuniform, it is expedient to deliberately make the speed of rotation of the abradant slightly different from that of the specimen.

V. Conclusions

The advantages of abrasion machines based upon the mathematical solutions presented in this paper are many. Such machines are applicable not only when testing the resistance to abrasion of textiles, but also appear to be applicable to many organic and inorganic materials, as well as in grinding, lapping, and polishing of plane surfaces. The structural details of the machines and of the abradants would have to be designed and selected specifically for each type of material. The optimum testing technique and method of evaluation of the test results would also have to be worked out for each material.

Acknowledgment

The author is especially grateful to Mr. Philip Miller, who assisted in the preliminary experiments which led to the solution of this very interesting problem; to John Krasny, who has carried out tests on many different textiles and assisted in the development of special clamps; and to Miss J. M. Blandford, who has prepared the illustrations for this paper.

Literature Cited

1. Dévé, Ch., Guide de L'Ouvrier en verres d'optique de precision, Revue d'Optique Théorique et Instrumentale, Paris, 1930. (English translation by Thomas L. Tippell, "Optical Workshop Principles," London, Adam Hilger Ltd., 1943.)
2. Gavan, F. M., Eby, S. W., and Schrader, C. C., New Sandpaper Abrasion Tester, *A.S.T.M. Bull.* **143**, 23–9 (1946).
3. Hall, H. S., and Kaswell, E. R., Wear-Resistance of Apparel Textiles: A Literature Survey, TEXTILE RESEARCH JOURNAL **15**, 178–89 (1945).
4. Haven, G. B., New Abrasion Machine, *Textile World* **76**, 2654–6, 2662 (1929).
5. Kessler, D. W., Wear Resistance of Natural Stone, RP612, *J. Research Natl. Bur. Standards* **11**, 635–48 (1933).
6. Larose, P., New Form Abrasion Tester, *Can. J. Research* **18**, 161–4 (1940).
7. Martindale, J. G., New Design Cloth Wearing Tester, *J. Text. Inst.* **33**, T151–8 (1942).
8. Schiefer, H. F., Wear Testing Carpets, RP1505, *J. Research Natl. Bur. Standards* **29**, 333–79 (1942).
9. Schiefer, H. F., Fourt, L., and Kropf, R. T., "Textile Testing in Germany." To be published by Textile Research Institute.
10. Sigler, P. A., and Holt, W. L., Simple Abrasion Test Machine for Rubber, *India Rubber World* **82**, 63–6 (1930).

Determination of Denier and Strength of Single Filaments by Vibroscope and Heim Tensile Tester

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THE vibroscope is an apparatus for determining the denier of short single filaments quickly and simply. When the denier of the filament has been determined vibroscopically, it can be fixed in an entirely undamaged condition in the Heim tensile tester, where its breaking strength is measured. The Heim tester, used alone, determines the absolute strength of the thread; but used in combination with the vibroscope it can give the relative strength of the thread in grams per 100 denier directly. This instrument can record the strength-elongation curve of the thread photographically, and hence without loss of power. For practical purposes, however, it is usually sufficient to record only the breaking strength and elongation of the fiber being examined, and for this purpose an optical system instead of a camera is attached to the Heim apparatus. By means of this optical system, breaking strength and elongation can be read from the apparatus directly. The whole determination takes only a few minutes, and for many years the method has been applied in the A.K.U. factories and laboratories for production control.

Besides furnishing data on strength and elongation, the vibroscopic measuring method makes it possible to collect data on the regularity of the denier. For a continuous-filament rayon these data are important, particularly when the spinneret employed has a great many holes and it is desired to determine the distribution of the denier over the filaments coming from the various holes.

In parts I and II of this article the characteristics and the operation of the vibroscope are discussed briefly, and in part III some experimental results are given.

I. Vibroscope

A filament of 1 den. with a length of 1 cm. weighs about 10^{-6} g. If such a filament is to be weighed with an accuracy of, say, 1 percent, it is necessary to have available a weighing method with a sensitivity of 10^{-8} g.

An indirect weighing method has been developed by the author of this article, the principle of which is outlined schematically in the insert in Figure 1. The filament to be examined is fixed in the thread clamp K of the vibrator, hangs over a smoothly polished steel pin S, and is kept in tension by the weight P. The clamp K is fixed to the mobile soft-iron tongue of a magneto-dynamic loud-speaker system. If an alternating current is put through the exciting coil of the loud-speaker system, the soft-iron tongue, and consequently the clamp K, will start vibrating, the direction of the vibration of K being at right angles to the direction of the thread. If the frequency of the alternating current which is supplied to the loud-speaker system is chosen equal to the resonance frequency of the filament, the filament will vibrate in standing waves, as shown in Figure 1 by the dotted curve.

A general formula for the natural frequency of a vibrating thread was given by Seebeck [1]—

$$\nu = \frac{1}{2l}\sqrt{\frac{P}{m}}\left[1 + \frac{R^2}{l}\sqrt{\frac{E\pi}{P}}\right], \qquad (1)$$

where:

ν = the frequency at which half the wave length equals the length of the thread between S and K;
R = the radius of the cross section of the thread, which is assumed to be circular;
P = the tension on the thread;
E = the elasticity modulus;
m = mass per unit length of the thread—(thus m is a measure of the denier of the thread).

By a suitable choice of P and l, the value of the factor $\frac{R^2}{l}\sqrt{\frac{E\pi}{P}}$ can become very small compared with 1. Then the classical formula for the reso-

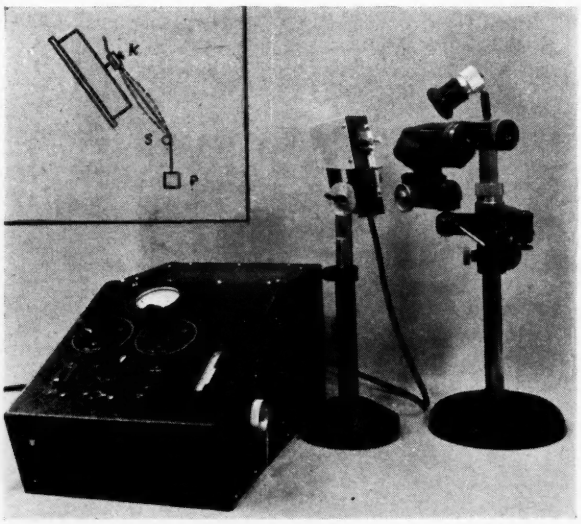

FIG. 1. *Apparatus for vibroscopic determination of denier, showing audiofrequency generator, vibrator, and Zeiss binoculars. The insert is a schematic diagram of the vibrator.*

nance frequency of a vibrating thread is left:

$$\nu = \frac{1}{2l}\sqrt{\frac{P}{m}}. \qquad (2)$$

Equation (2) shows that at a certain clamped length, SK, and a certain tension, P, the resonance-frequency ν of the vibrating thread is a measure of the denier of the thread, independent of its cross-sectional shape.

Practically, it is not possible to make the value of the factor $\frac{R^2}{l}\sqrt{\frac{E\pi}{P}}$ negligibly small compared to 1. Were it possible, this would be done by choosing large values for l and P. It is, however, not permissible to choose l arbitrarily great, as it must be possible to measure the length of the cut filaments; nor can P be made very high, as the filament would then be elongated too much. For filaments of 1 to 2.5 denier, l can be 2 cm. and P, 20 mg. For this case, the factor $\frac{R^2}{l}\sqrt{\frac{E\pi}{P}}$ is of the order of magnitude of 0.01 if the filament is a normal rayon. Thus, the factor $\frac{R^2}{l}\sqrt{\frac{E\pi}{P}}$ gives a "correction" for the value of ν from equation (2), which in this case amounts to about 1 percent.

For threads of 2.5 to 5 denier, l can be 4 cm. and P, 160 mg. The correction then amounts to 0.02. For the measurement of threads of from 3 to 7 denier, l can be 4 cm. and P, 240 mg. In this case the correction is 0.02 to 0.03. In all cases the correction increases with the increase of the denier of the thread. This correction may not be omitted since a correction in ν of from 0 to 3 percent in the cases considered above means a correction of from 0 to about 6 percent in the determination of the denier.

This correction is made empirically: a certain length is cut from a normal rayon yarn and weighed with the aid of a sensitive torsion balance to obtain the average denier of the filaments. Then every single filament is measured vibroscopically. In this way the average resonance frequency can be determined for a certain filament denier at a certain gage length l and tension P. Thus the vibroscope can be calibrated empirically. In making this calibration it is, of course, of great importance to manipulate the filaments very carefully. After the yarn has been weighed on the torsion balance the filaments must be removed from the yarn in order to be measured vibroscopically. During this manipulation the threads must not be stretched, since the resonance frequencies on the vibroscope would then be too high. Our experience shows that if the filaments are handled carelessly, the calibration of the vibroscope will be from 2 to 3 percent too low.

The aluminum weight P (Figure 1) is fixed in place by means of a very small piece of cellophane

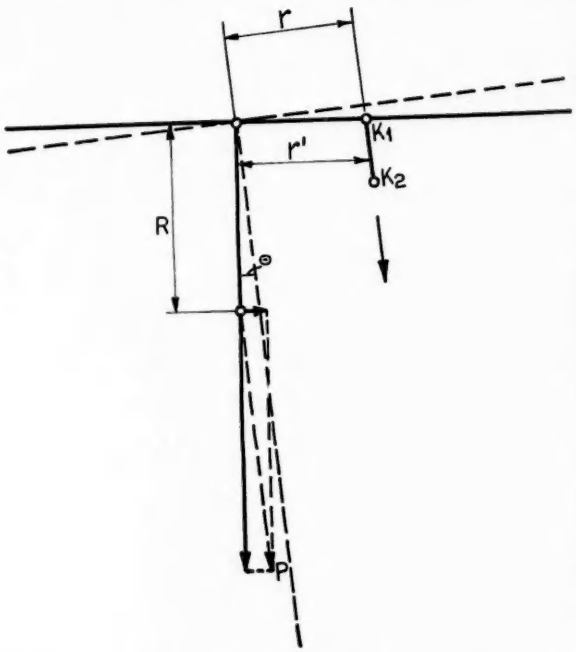

FIG. 2. *Diagram showing the principle of operation of the Heim tensile tester.*

adhesive tape. Fixing this weight, clamping the thread in the vibrator, and making the measurement can be completed within 2 minutes. The undamaged thread can then be removed from the vibrator and can immediately be clamped in the Heim instrument to be subjected to the breaking test.

On the left in Figure 1 is the audio-frequency generator, by means of which an alternating current of arbitrarily chosen frequency is excited. The scale of this instrument is calibrated to indicate the denier directly. The frequency of the generator ranges from about 500 to 1,200 cycles per second. The instrument is calibrated very simply by the aid of a self-contained tuning fork, the calibration leading to an adjustment of the frequency scale that is accurate to within 1 per mille. The generator is of the low-frequency type; the self-inductance and capacity of the L-C circuit are high and the frequency is varied by adjusting L by sliding an iron core into or out of the self-inductance coil. Such a generator has great frequency stability.

The vibrator, in which the filament is clamped, is shown in the center of Figure 1. On its right is a Zeiss binocular magnifying glass (magnification 50 ×), by means of which the thread is observed during the adjustment to maximum amplitude (resonance).

The loud-speaker system (vibrator) must meet the highest requirements. In the frequency range

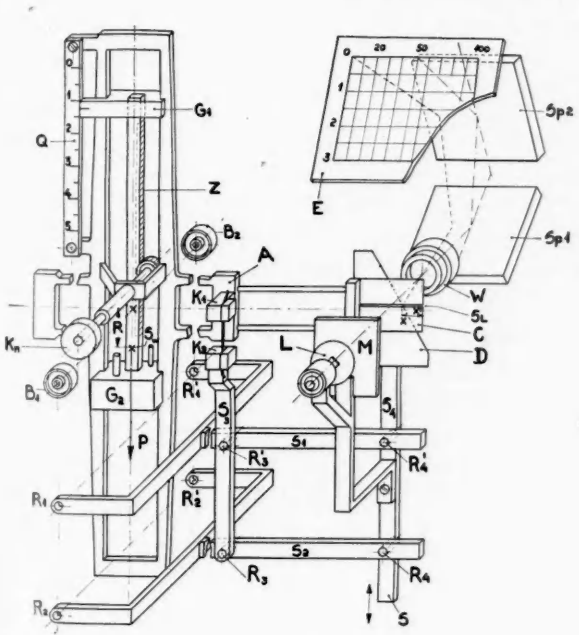

FIG. 3. *Construction of the Heim tensile tester.*

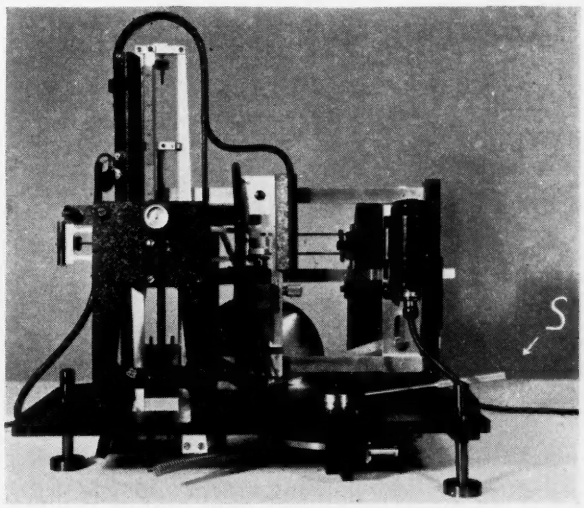

FIG. 4. *Photograph of the Heim tensile tester.*

in which the measurements are carried out, this system may not possess mechanical natural resonances. Even small mechanical natural resonances which are entirely inaudible can influence the resonance frequency of the filament. Therefore, when the vibrators are checked for serviceability, they are accurately tested for mechanical natural resonances with the aid of a crystal microphone and cathode-ray oscillograph.

It is clear that the threads which are to be examined vibroscopically must be chosen carefully. Cotton and wool, for example, cannot be considered to be homogeneous threads with the same cross section throughout. Rayon, casein fiber, nylon, and other types of artificial threads will better satisfy the standards set by equation (2). The application of the vibroscopic denier determination lies particularly in the field of the last-mentioned types of thread. Of course, wool and cotton can be examined vibroscopically as well, but the error of measurement will be greater than the 1 percent error involved in measurements on artificial fibers.

II. Heim Tensile Tester

Osumi and Kato [2] distinguish four principal types of strength-testing apparatus—viz., the hydrostatic type, the balance type, the pendulum type, and the spring type. According to this classification, the Heim apparatus belongs to the pendulum type. This tester was developed by G. Heim in the Research Laboratory of the A.K.U. at Arn-

hem, Holland. Its characteristic properties may be summarized as follows:

1. It has very small bearing friction.
2. The recording of strength and elongation is frictionless.
3. Strength and elongation values are read on a "practically" rectangular system of coordinates.
4. It is a sturdy instrument with few vulnerable parts.
5. It is simple to handle.

The operation of the Heim tester is schematically shown in Figure 2. The thread is fixed between the clamps K_1 and K_2; clamp K_2 moves in a downward direction at constant velocity. The force T, which is exerted on the filament by the balance arm, is given by the well-known formula

$$T = \frac{PR \sin \theta}{r}, \tag{3}$$

where r may be considered practically equal to r' since the angle of deflection θ remains small.

Figure 3 shows the construction of the apparatus and Figure 4 is a photograph of it. The balance arm A (Figure 3), to which the upper clamp K_1 is fixed, can rotate in the ball bearings B_1 and B_2, which have been indicated separately to simplify the figure. In the latest working arrangement of this apparatus, the ball bearings have been replaced by knife-edge supports. The filament to be examined is fixed to the clamps K_1 and K_2. The apparatus is set in operation when clamp K_2 starts moving downward. Clamp K_2 is fixed to the bar system S_1, S_2, S_3, S_4; R_1–R_1', R_2–R_2', R_3, R_3', R_4, R_4' are pinions. Thus, when the extreme end S of this bar system moves downward, the bars S_1 and S_2 rotate around the pinions R_1–R_1' and R_2–R_2'. Owing to the pivoting action of R_3, R_3', R_4, and R_4' the bars S_3 and S_4 remain perpendicular. Thus, the relative position of the clamp K_2 remains the same. The path described by the clamp K_2 is a circular arc, but the length of arc covered by the clamp during operation is small as compared with the radius of the arc, so that the path can be considered practically a straight line. This applies likewise to the path described by the clamp K_1.

Since starting the instrument makes point S move downward mechanically at constant velocity, clamp K_2 also moves downward at constant velocity. Should the filament which has been clamped in not stretch, the tension T, which is exerted on the filament, increases in the first instance according to the formula

$$T = P\left(\frac{R}{r}\right)\alpha t, \tag{4}$$

where α is a constant. This formula applies only to small angles of deflection. As the filament elongates, the tension T is smaller than that indicated by equation (4). Then

$$T = P\left(\frac{R}{r}\right)[\alpha t - \phi(t)], \tag{5}$$

where the quantity $\phi(t)$ is connected with the elongation of the filament during stretching. Equation (5) shows that the tension T as a function of the time during stretching also depends on the specific elongation properties of the filament under examination. In principle, the well-known strength-testing apparatus of Baer, Schopper, Goodbrand, and Tänzer operates in this way [3]. It must be pointed out that equations (4) and (5) apply only to the first stage of the stretching process. As the angle of deflection increases a complicated relationship between T and t will be involved since the distance r in Figure 2 can no longer be considered constant.

The optical system for strength-elongation recording on the Heim tester is shown schematically in the upper right-hand corner of Figure 3. This direct-reading arrangement will now be considered more closely. At the end of the balance arm A there is a thin metal plate C in which the slit SL has been cut. Overlapping part of this slit is the metal plate D, which is fixed to the bar S_4 and is very close to plate C. When a filament is stretched, the clamp K_2 moves downward. Then:

1. If the filament does not elongate, the metal plates C and D move downward with equal velocities, and the position of the plates relative to each other does not change.

At a given moment the perpendicular displacement of the slit SL is a measure of the tension T exerted on the filament by the balance arm A.

2. If the filament elongates, then the movement of the metal plate C will be slower than that of the plate D and a smaller part of the slit SL is covered.

Thus, the increase in the uncovered part x–x′ of the slit SL is a measure of the elongation of the filament.

The lamp L illuminates the milk glass plate M. This plate ensures a regular illumination of the slit SL which is reproduced on the ground-glass plate E

by means of the lens W and the two aluminum mirrors Sp_1 and Sp_2. Figure 3 shows what is observed when a filament is being stretched. A horizontal strip of light, which is the image of the uncovered part of slit SL, appears on the ground-glass plate E, the extreme right-hand end of the strip, indicating the values of tension and elongation at any moment. Tension is read from the top of the plate downward, and elongation from left to right.

The scale values for strength and elongation can easily be determined empirically. By hanging weights on the clamp K_1, we find the vertical scale value for the tension T, and by measuring the distance between the clamps K_1 and K_2 for various angles of deflection of the balance arm we find the horizontal scale value for the elongation. Clearly, the system of coordinates which can be drawn out on the plate E after empirical calibration of the apparatus cannot be a rectangular system. Nevertheless, the coordinates are not so distorted that the strength and elongation cannot be read easily. While the filament is being stretched, the operator follows the right-hand end of the light strip by hand, using a wooden stylus. In this way, the point where the filament breaks can be indicated and the strength and elongation at break can be read immediately.

As has already been mentioned, the strength-elongation curve can be recorded photographically. About 20 diagrams can be recorded on a film strip. The exposed strip is collected in a box fixed to the camera; a device cuts off the exposed from the unexposed film, and the box containing the exposed film strip is removed from the camera and taken to the darkroom.

As stated in the introduction to this paper, the scale value of the filament load can always be read in g./100 den. This is possible for the following reasons. If for any given deflection angle of the balance arm the load on the filament is made proportional to the denier of the filament, the load scale on the plate E, measuring strength in g./den., will apply to any filament that is tested. From this, the strength in g./100 den. can be obtained immediately. According to equation (3), the filament load at a certain angle of deflection θ of the balance arm can be increased by altering either P or R. Thus, for a given P a whole range of filament deniers can be embraced by variation of R. Figure 3 shows that two displaceable weights G_1 and G_2 are included in the balance arm. By means of the knob Kn and the driving gear, they can be moved up and down. The displacement of this pair of weights results in the same displacement of the center of gravity on the balance arm and hence a variation in R (see Figure 2). This displacement is indicated on a scale Q, which is calibrated from 0 to 5 in such a way that the scale reading corresponds to the denier of the fiber being tested.

In practice, then, the weights are displaced until the reading on the scale Q corresponds to the denier of the fiber, and then the strength of the fiber can be read from the apparatus in g./den. When filaments of 5 to 10 den. are to be tested, the displaceable weight is doubled by the addition of suitable weights, and the Q-scale setting is made equal to half the fiber denier.

Some data on the Heim tensile tester follow.

The velocity of the lower clamp (K_2) is 1 cm./min.

The time required to break a filament depends on the material and on the adjustment of the balance. It is usually about 30 sec.

The 220–380-v. A.C. driving motor runs constantly. To start the apparatus, the motor is coupled mechanically with the driving mechanism.

For direct reading the same objective is used as for photographic recording—viz., a Leitz Mikro Summar 35 mm., F = 4.5.

The Q scales run

1. From 0 to 5 den. The maximum measurable strength is 3 g./den.
   The maximum measurable elongation values are dependent on the strengths of the filaments under examination. They can vary from about 150 percent at small strength to 70 percent at 3 g./den.
2. From 5 to 10 den. In this range, measurements can be obtained by making the load in the balance arm twice as large as in the preceding case.
3. From 10 to 25 den. In this case, the load on the balance arm is made five times as large as in case 1.

III. Results of Some Determinations Carried Out with Heim Tester and Vibroscope

A. In order to check the regularity of the denier of one rayon filament, a number of denier determinations were carried out with the Vibroscope and

TABLE I. RESULTS OF VIBROSCOPIC DENIER DETERMINATION ON EACH FILAMENT OF A RAYON YARN FOR A NUMBER OF SAMPLES OF EACH OF THREE DIFFERENT YARNS

Yarn	Number of determinations	Average denier	Standard deviation (%)	
100 den. 40 fil.	40	2.45	5.8	average 7.0%
	40	2.48	8.3	
35 den. 8 fil.	8	4.32	4.7	
	8	4.12	4.8	
	8	4.17	5.8	
	8	4.12	4.3	
	8	4.15	4.2	average 4.9%
	8	4.21	6.0	
	8	4.19	5.1	
	8	4.16	5.5	
	8	4.19	4.2	
	8	4.21	4.4	
100 den. 40 fil. (2 determinations carried out on each filament)	80	2.83	5.5	
	80	2.88	8.8	
	80	2.80	7.1	average 6.6%
	80	2.83	6.0	
	80	2.73	5.5	

the standard deviation in percent of the average value was ascertained.

Number of determinations	Standard deviation (%)
13	2.9
18	4.5
Average	3.7

This average deviation of about 4 percent may be considered to be caused by the irregularity of the filament since the reproducibility of the vibroscopic measurement itself is very high.

B. The denier of all the filaments of two samples —100 den. 40 fil., and 35 den. 8 fil.—was determined and the standard deviation was calculated. The results in Table I show that the standard deviation in filament denier of about 6.5 percent, obtained by making one measurement on each filament of a yarn, is greater than the deviation of 3.7 percent, obtained by making a number of measurements on a single filament; that is, the variations in denier from filament to filament in a normal yarn are greater than those within one filament.

C. The denier of 20 to 80 fibers of each of 11 samples of staple fiber and of 3 samples of casein fiber was measured and the standard deviation was calculated.

TABLE II. RESULTS OF VIBROSCOPIC DENIER DETERMINATION ON FILAMENTS OF STAPLE FIBERS AND CASEIN FIBERS

Material	Number of measured filaments or number of determinations	Standard deviation of the denier determination (%)	Average denier
Dura flox	160	20	—
Flox	35	12.4	1.40
Vistra	20	10.2	3.55
Phrix	80	18.8	1.57
Fibramin	50	24.8	3.08
Cuprama	50	22.9	1.70
Phrix	80	21.4	1.64
Glauchau	80	13.3	1.39
Courtaulds	80	13.3	1.53
Twentenka yarn K.S.W.	80	14.9	2.19
Courtaulds yarn	80	21.1	1.55
	Average	17.5	
Casein fiber (Ede)	19	15	
	20	20	
	18	16	
	Average 18		

Summarizing: Standard deviation in %
Staple fiber average 17.5%; varies from 12% to 25%
Casein fiber average 18.0%

The results in Table II show that in this case the irregularity between the fibers is strikingly greater than in the case of continuous-filament rayon. This irregularity may be caused either by the clogging of holes or by the difference in conditions between the filaments at the outside of the cable and those at the inside of the cable leaving the spinneret. Such a great deviation occurs in a great many types of staple fiber.

D. Determinations were carried out on the natural fibers, cotton and wool. The data of Table III were determined from two types of cotton of sufficiently long staple length and from three types of wool. These determinations show that the irregularity of the denier of these fibers is greater than that of the samples of staple fiber. The strength of the wet cotton fiber is greater than that of the dry fiber.

E. The usual method for determining the strength of fibers is the so-called flat bundle method, which has been standardized by the A.S.T.M. (D 540–44): A bundle of fibers is weighed by a torsion balance after being cut to exactly 20 mm. Then it is stretched on a dynamometer of suitable measuring range. Some experimental results which

TABLE III. RESULTS OF VIBROSCOPIC DENIER DETERMINATION AND OF BREAKING STRENGTH AND ELONGATION AS MEASURED BY THE HEIM TENSILE TESTER FOR SOME WET AND DRY COTTON AND WOOL FIBERS

	Denier	Standard deviation denier determination	Strength 100 denier Dry	Strength 100 denier Wet	Elongation Dry	Elongation Wet	Number of determinations
American cotton, $1\frac{3}{16}$ inch	1.87	18%	234	272	9	12	25
Sea Island cotton	1.73	24%	296	306	8	10	25
Australian wool, combed	3.87	34%	155	126	39	52	25
Short wool fibers, combed	4.16	26%	146	102	45	57	25
Long wool fibers, combed	8.17	18%	165	120	47	63	25

TABLE IV. A COMPARISON OF FIBER STRENGTHS AS MEASURED BY THE HEIM TENSILE TESTER AND THE FLAT BUNDLE METHOD

	Strength in g. per 100 den.		Strength in lbs./sq. in.		Strength ratio	
	Flat bundle method	Heim tester method	Flat bundle method	Heim tester method	Flat bundle method	Heim tester method
Staple fiber	143	235	27.80	45.7	61%	
Sea Island cotton	194	296	37.75	58.0	65%	
American cotton	175	234	34.05	45.4	75%	

TABLE V. EXAMPLE OF ROUTINE DETERMINATIONS OF DENIER, STRENGTH, AND ELONGATION OF STAPLE FIBER SAMPLES

	Sample	Denier	Heim strength g./100 den. (dry)	Standard deviation (%)	Elongation % (dry)	Number of determinations	Heim strength g./100 den. (wet)	Standard deviation (%)	Elongation % (wet)	Number of determinations
I	5 den. 2 in.	5.37	116	20.9	37	40	74	6.2	57	20
II	3 den. 2 in.	3.18	142	3.7	26	20	82	3.2	41	20
III	3 den. 2 in.	3.28	247	12.3	24	20	137	9.6	27	20
IV	1.5 den. $1\frac{7}{16}$ in.	1.62	255	11.2	17	20	128	12.6	24	20
V	1.5 den. $1\frac{9}{16}$ in.	1.48	208	16.8	17	40	107	16.8	23	40
VI	3 den. 1.5 in.	3.00	141	11.8	38	20	87	10.7	52	20
VII	1.5 den. 1.5 in.	1.63	288	7.0	17	20	161	8.6	23	20
VIII	1.5 den. $1\frac{7}{16}$ in.	1.60	212	20.0	19	60	113	16.5	28	40
IX	1.5 den. $1\frac{7}{16}$ in.	1.69	263	6.7	18	40	137	10.2	23	20
X	1.5 den. $1\frac{9}{16}$ in.	1.70	244	17.5	20	40	124	20.7	23	40
XI	1.5 den. 1.5 in.	3.33	109	17.6	21	40	72	17.9	38	40
XII	1.5 den. $1\frac{7}{16}$ in.	1.66	250	11.7	17	40	140	8.5	25	20
XIII	Fibrenka	1.51	246	9.9	15	20	123	10.8	19	20

compare the fiber strength as measured by the flat bundle method and by the Heim tester are shown in Table IV.

Table IV shows that the flat bundle method gives a strength which is only about 60 to 70 percent of the strength as measured on the individual fiber. The low strength of cotton which has been determined according to the flat bundle method must be attributed to the irregularity in strength of the examined sample (the standard deviation of the Heim strength of the cotton samples amounted to about 40 percent for 50 individual observations). For an unambiguous measurement of the properties of fibers, the use of the vibroscope and the Heim tester is to be preferred to methods which weigh or stretch a number of fibers at the same time.

F. The data from normal routine determinations on staple fibers given in Table V convey an idea of the results obtained with the Vibroscope and Heim instrument as it is used in the A.K.U. factories and laboratories. Results of a number of determinations of denier, strength, and elongation of various samples of staple fiber are recorded.

Literature Cited

1. A. Wüllner, *Lehrbuch der Experimentalphysik*, Bd. 1: "Allgemeine Physik und Akustik," 1907, p. 799.
2. G. Osumi and E. Kato, *J. Text. Inst.* **28**, T129 (1937).
3. E. Tänzer, *Melliand Textilber.* **8**, 858, 938, 1013 (1927).

Analysis of Tear Strength

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Contribution from the Research Laboratories of Rohm & Haas Co., Philadelphia, Pennsylvania

Abstract

An analysis has been made of the factors involved in the A.S.T.M. Trapezoid Tear-Strength Test. The tear strength of a fabric measured by this test is dependent mainly on the extensibility of the threads, the breaking strength of the threads, the effective specimen length, and the number of threads per inch of fabric. An analytical interpretation of the part played by each of these factors resulted in a general equation relating tear strength to the breaking strength and extensibility of a given fabric. The evaluation of the derived equation gave a good correlation between the calculated and measured tear-strength values of the fabrics investigated.

I. Introduction

During the course of an investigation on modified celluloses, it became important to measure and interpret the changes produced in the mechanical properties of fibers, yarns, and fabrics, by chemical modification of the cellulose. It had been noted that chemical treatments which markedly altered the character of the load-elongation of single yarns also produced important changes in the tear-resistance of fabrics. Moreover, an empirical relationship had been found in this laboratory between the value of the A.S.T.M. Tear Test [1] and the toughness [2] of a fabric. This relationship had shown that the tear strength was highly dependent upon the extensibility of the individual yarns.

In view of the interest in the tear strength of chemically modified cellulosic fabrics, it was decided to interpret analytically the action of the A.S.T.M. Trapezoid Tear Test, and to explore the possibility of calculating tear strength from the usual breaking strength-extensibility data.

II. Analysis of Tear Strength

In deriving the relationship between tear strength and the breaking strength and extensibility of fabrics, the following simplifying assumptions can be made:

1. The yarns or threads in a fabric are of uniform strength and extensibility.
2. When under stress, the threads obey Hooke's Law up to the point of rupture.
3. The distance between thread centers is uniform.
4. The cross threads do not influence the tear value.

Figure 1 shows the dimensions of the standard A.S.T.M. test piece. From the geometry of the specimen, it is observed that the length of any thread ab is $l_0 + d$, where d is the distance of the thread ab from a shorter one of length l_0. The extra length d in thread ab is extra slack over and above that which may exist in the shorter thread l_0, when the specimen is disposed between parallel jaws. In the A.S.T.M. specification an initial slit (s), $\frac{1}{4}$ to $\frac{3}{8}$ of an inch long, is made in the test specimen. Therefore, when the separation of the jaws is such that the first intact thread is just taut but still unstretched, the lengths of the successive threads, which are assumed to be equal in properties and uniformly separated from each other by a distance d, are given by the following:

$$
\begin{aligned}
l_1 &= (1 + s) + d \times 0 = l_1 + d \times 0 \\
l_2 &= (1 + s) + d \times 1 = l_1 + d \times 1 \\
l_3 &= (1 + s) + d \times 2 = l_1 + d \times 2 \\
&\cdots \\
l_{(n-1)} &= (1 + s) + d(n - 2) = l_1 + d(n - 2) \\
l_{(n)} &= (1 + s) + d(n - 1) = l_1 + d(n - 1)
\end{aligned}
$$

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[1] A.S.T.M. specification D39–39, 1944 Standards, p. 78.
[2] Toughness $= \frac{\text{Breaking strength} \times \text{extensibility}}{2}$ (Harold DeWitt Smith, A.S.T.M. Edgar Marburg Lecture, 1944).

If the threads are of uniform strength and extensibility, and if they comply with Hooke's Law up to the point of rupture, the total restraining force exerted by the threads on the jaws is the sum of the separate forces exerted by those threads which are brought into action when the jaws are separated by an amount equal to the breaking elongation (e_B) of the first intact thread. Let Hooke's Law be given by

$$f^1 = k\frac{e}{l} = kL^1, \tag{1}$$

where L^1 is the fractional elongation. The special circumstance represented by a thread having been elongated to the point of rupture (e_B) is given by

$$f = k\frac{e_B}{l} = kL, \tag{2}$$

where L = fractional extensibility.

It is also useful to note that

$$f = k\frac{e_B}{l} = k\frac{E_B}{l_B}, \tag{3}$$

where E_B = actual elongation at break, l_B = original taut but unstretched length of thread which was stretched an amount E_B, and

$$e_B = Ll; \tag{4}$$

then

$$f_1 = k\frac{e_B - d \times 0}{l_1} = k\frac{Ll_1 - d \times 0}{l_1 + d \times 0}$$

$$f_2 = k\frac{e_B - d \times 1}{l_2} = k\frac{Ll_1 - d \times 1}{l_1 + d \times 1}$$

$$f_3 = k\frac{e_B - d \times 2}{l_3} = k\frac{Ll_1 - d \times 2}{l_1 + d \times 2}$$

$$\vdots \qquad\qquad \vdots$$

$$f_{(n-1)} = k\frac{e_B - d \times (n-2)}{l_{(n-1)}} = k\frac{Ll_1 - d(n-2)}{l_1 + d(n-2)}$$

$$f_{(n)} = k\frac{e_B - d \times (n-1)}{l_n} = k\frac{Ll_1 - d(n-1)}{l_1 + d(n-1)}$$

The summation of f for n terms is given by:

$$\sum_1^n f = kLl_1\left(\frac{1}{l_1} + \frac{1}{l_1 + d} + \frac{1}{l_1 + 2d} + \cdots \frac{1}{l_1 + (n-2)d} + \frac{1}{l_1 + (n-1)d}\right) - kd\left(\frac{1}{l_1 + d} + \frac{2}{l_1 + 2d} + \frac{3}{l_1 + 3d} + \cdots \frac{n-2}{l_1 + (n-2)d} + \frac{n-1}{l_1 + (n-1)d}\right). \tag{5}$$

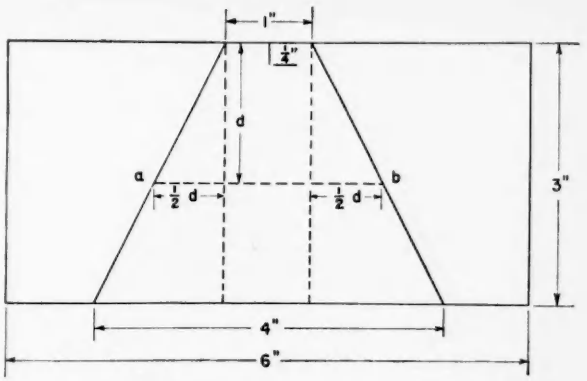

FIG. 1. *A.S.T.M. Trapezoid Tear-Test specimen.*

To what extent summation needs to be continued is determined by the order of the thread which is no longer slack but is also not exerting a restraining force on the jaws—that is, for which $f_n = 0$. Therefore summation must cease when

$$f_n = 0 = e_B - d(n-1), \tag{6}$$

from which

$$n = \frac{e_B}{d} + 1 = \frac{Ll_1}{d} + 1. \tag{7}$$

However, since this n-th thread contributes nothing to the tearing strength, summation is actually stopped after the $(n-1)$-st thread, or the last term is:

$$f_{(n-1)} = k\frac{e_B - d(n-2)}{l_{(n-1)}} = k\frac{Ll_1 - d(n-2)}{l_1 + d(n-2)}. \tag{8}$$

Substituting

$$n - 1 = \frac{Ll_1}{d}, \tag{9}$$

the tearing force becomes

$$F_t = \sum_1^n f = k\left[Ll_1\left\{\frac{1}{l_1} + \frac{1}{l_1 + d} + \frac{1}{l_1 + 2d} + \cdots \frac{1}{l_1 + \left(\frac{Ll_1}{d} - 1\right)d}\right\} - d\left\{\frac{0}{l_1} + \frac{1}{l_1 + d} + \frac{2}{l_1 + 2d} + \cdots \frac{\frac{Ll_1}{d} - 1}{l_1 + \left(\frac{Ll_1}{d} - 1\right)d}\right\}\right]. \tag{10}$$

From the usual type of breaking-strength test, determined on the same fabric,

$$F_B = Nk\frac{E_B}{l_B} = NkL, \tag{11}$$

where F_B = observed breaking strength (raveled strip method), E_B = observed elongation of specimen at break, l_B = original specimen length used in the test, and N = number of threads in the test specimen. Hence

$$k = \frac{F_B}{Nl} = \frac{f_B}{L}. \tag{12}$$

Substituting in equation (10):

$$F_t = f_B\left[\, l_1\left(\frac{1}{l_1} + \frac{1}{l_1 + d} + \frac{1}{l_1 + 2d} + \cdots \frac{1}{l_1(1 + L) - d}\right) - \frac{1}{LC}\left(\frac{0}{l_1} + \frac{1}{l_1 + d} + \frac{2}{l_1 + 2d} + \cdots \frac{(Ll_1C - 1)}{l_1(1 + L) - d}\right)\right], \tag{13}$$

where $C = \frac{1}{d}$ = number of threads per inch.

In a general form equation (13) becomes:

$$F_t = f_B\left[\, l_1(A) - \frac{1}{LC}(B)\,\right]. \tag{14}$$

Although this equation looks formidable, in practice it can easily be reduced to a table of values for any given fabric. That this is possible is evident when it is realized that the values in the series terms A and B are constants, fixed by the test procedure and the construction of the fabric being tested. By forming a table of values for the terms A and B for any value of n and for a particular fabric, the tear strength can be readily calculated from the usual breaking strength-extensibility curve. An example for such a calculation, based on one of the fabrics given in Table II (G-90), follows.

Problem: Calculate the tear strength of a fabric having the following properties:

Breaking strength (F_B)	= 36.5 pounds
Elongation at break (E_B)	= 0.27 inch
Thread count (C)	= 90 per inch

Solution: The remaining terms of equation (13) have the following values:

$$s = 0.25 \text{ inch}$$
$$l_1 = 1.25 \text{ inches}$$
$$d = \frac{1}{C} = 0.0111 \text{ inch}$$
$$L = \frac{0.27}{3} = 0.09$$
$$f_B = \frac{36.5}{90} = 0.405 \text{ pound}$$

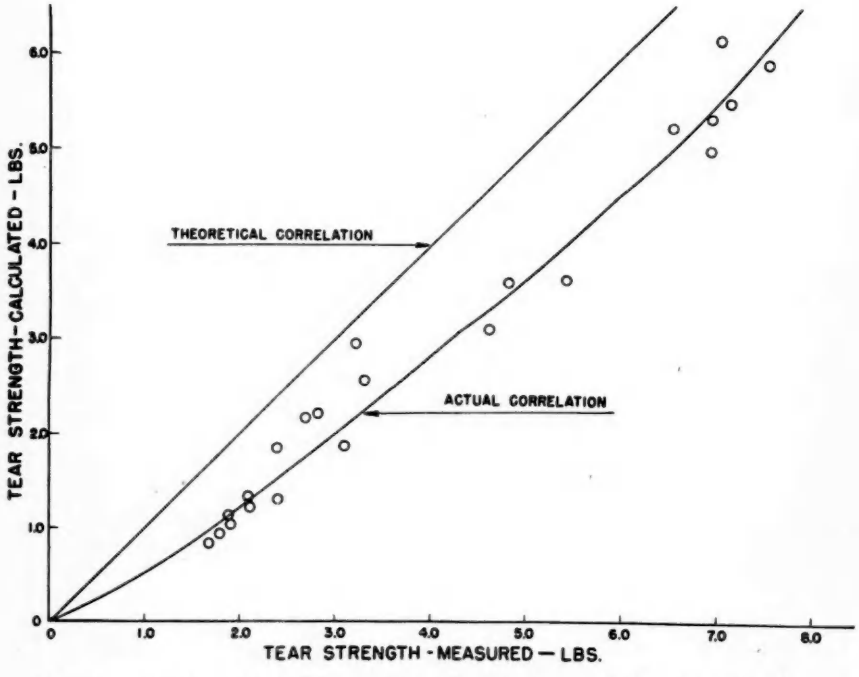

FIG. 2. *Relationship between calculated and measured tear-strength values.*

The final term in the two series A and B has a denominator given by

$$l_1(1 + L) - d = 1.25(1 + 0.09) - 0.0111 = 1.352.$$

In Table I are given values of the terms A and B of equation (14) for a fabric having a thread count of 90 threads per inch. This table reveals that the tenth term has a value nearest to 1.352. We therefore take as values of A and B the following:

$$A = 7.698,$$
$$B = 34.095.$$

TABLE I. CALCULATED VALUES FOR THE SERIES TERMS OF EQUATIONS (13) AND (14)

Thread No.	$l_1^* + d\dagger$	$\frac{1}{l_1 + d}$	(A)	$\frac{n-1}{l_1 + d}$	(B)
1	1.2500	0.800	0.800	0.000	0.000
2	1.2611	0.793	1.593	0.793	0.793
3	1.2722	0.786	2.379	1.572	2.365
4	1.2833	0.780	3.159	2.340	4.705
5	1.2944	0.773	3.932	3.092	7.797
6	1.3055	0.766	4.698	3.830	11.627
7	1.3166	0.760	5.458	4.560	16.187
8	1.3277	0.753	6.211	5.271	21.458
9	1.3388	0.746	6.957	5.968	27.426
10	1.3499	0.741	7.698	6.669	34.095
11	1.3610	0.736	8.434	7.360	41.455
12	1.3721	0.729	9.163	8.030	49.485
13	1.3832	0.723	9.886	8.675	58.160
14	1.3943	0.717	10.603	9.315	67.475
15	1.4054	0.712	11.315	9.960	87.435
16	1.4165	0.706	12.021	10.580	98.015
17	1.4276	0.701	12.722	11.220	109.230
18	1.4387	0.696	13.418	11.830	121.060
19	1.4498	0.690	14.108	12.420	133.480
20	1.4609	0.685	14.793	13.020	146.500

* $l_1 = 1.25$ inches.

† $d = \frac{1}{90} = 0.0111$ inch.

By equation (14), the tear strength becomes

$$F_t = 0.405\left(1.25 \times 7.698 - \frac{34.095}{0.09 \times 90}\right),$$

$$F_t = 0.405(9.61 - 4.21),$$

$$F_t = 2.19 \text{ pounds.}$$

III. Evaluation and Discussion of the Derived Equation

In order to test the validity of the equation derived in section II, the tear strength of a series of rayon fabrics was calculated. This group of fabrics consisted of the same basic fabric, but each fabric sample had received a different chemical treatment and was handled in such a way that the thread count was unaltered. The values of the terms A and B for this fabric, having a thread count of 90 threads per inch in the warp direction, are given in Table I for various values of n. In Table II are given the breaking strength, extensibility, and the calculated and measured tear-strength values. The measured tear values represent the mean of five replicates. The correlation between calculated and measured tear strength is graphically presented in Figure 2.

TABLE II. RELATIONSHIP BETWEEN CALCULATED AND MEASURED TEAR STRENGTHS

Sample No.	Breaking strength (lbs./in.)*	Elongation at break (in.)*	Tear strength measured (lbs.)†	Tear strength calculated (lbs.)	Difference (M-C)
G-135	27.1	0.13	1.7	0.88	0.8
G-132	26.6	0.15	1.8	0.96	0.8
G-129	27.8	0.16	1.9	1.06	0.8
G-120	25.8	0.18	1.9	1.10	0.8
G-117	28.4	0.20	2.1	1.32	0.8
G-114	30.5	0.20	2.4	1.42	1.0
G-126	34.0	0.24	2.4	1.85	0.5
G-96	34.3	0.25	3.1	1.93	1.2
G-93	37.0	0.26	2.7	2.15	0.5
G-90	36.5	0.27	2.8	2.19	0.6
G-111	40.1	0.29	3.3	2.55	0.7
G-87	40.6	0.33	3.2	2.90	0.3
G-81	41.0	0.40	4.6	3.07	1.5
G-78	43.2	0.44	4.8	3.62	1.2
G-75	43.5	0.44	5.4	3.64	1.8
G-84	48.4	0.55	6.5	5.25	1.2
G-123	46.2	0.56	6.9	5.00	1.9
G-72	49.4	0.56	6.9	5.35	1.5
G-99	48.7	0.58	7.1	5.50	1.6
G-66	52.3	0.61	7.0	6.19	0.8
G-69	49.8	0.61	7.5	5.90	1.6
				Average difference =	1.0

* Mean of 10 replicates.
† Mean of 5 replicates.

Examination of Figure 2 reveals that a definite correlation exists between calculated and measured tear-strength values. Although this correlation does not give a 1:1 ratio, the agreement is good, considering the assumptions made in the development of the equation. The differences between calculated and measured tear strengths average 1 pound for the twenty-one fabrics examined. An analysis of the order and magnitude of these differences by the delta test (a statistical test for trends or patterns) shows that at the 95-percent confidence level the test is indecisive, indicating that more data are required before conclusions can be drawn about the trend of the differences. Observation reveals—and this is verified by the delta test—that the ratios of measured to calculated values $\left(\frac{M}{C}\right)$ show a highly significant trend, due chiefly to the first five or six low values near the origin of the correlation curve given in Figure 2.

It is of interest to examine the possible causes for the small deviations observed between the calculated and measured tear-strength values. Obvi-

ously, the ideal conditions imposed upon the fabrics are not realized in practice. Moreover, the analysis is based on several assumptions, two of which do not fully hold when actual fabrics are considered. These two assumptions are that d, the distance between thread centers, remains constant even during the time of testing, and that the cross threads do not influence the tear strength. Observations made on fabrics during the testing procedure reveal that neither is the case. The ideal value of d does not exist while the sample is being torn, and the cross threads do exert some influence over the tear strength. Figure 3 is a schematization of the test specimen between the jaws of the I.P. Tester. It is noted that because of the inclination of the specimen, d' is the distance which the threads would assume when the jaws of the machine are moved apart. The two distances d and d' are related by the following:

$$d' = \frac{\sqrt{5}}{2} d.$$

Actually, d' is never attained in practice because of the restraining influence of the cross threads. This restraint causes a crowding together of those threads which are under tension, which results in a low value of d and an increase in the resistance to tear. The restraining effect of the cross threads is not constant but varies, during the period of test, with the number of threads broken and the number remaining unbroken between the jaws of the tester.

It is important to realize that the A.S.T.M. tear-strength value does not represent a fundamental property of a fabric. On the basis of equation (13) and experimental observations, the tear strength of a fabric can be made to have any value, within a wide range, simply by changing the distance between the jaws of the machine; that is, tear strength is highly dependent on the length of the first thread in the specimen. Figure 4 shows this dependence of tear strength upon the effective specimen length. Plot A represents the measured tear strength of a fabric as a function of the distance between the jaws of the machine. This fabric had a thread count of 90, a breaking strength of 50 pounds, and a fractional extensibility at break of 0.2 inch. The tear value for a jaws' separation of zero ($l_1 = 0 + 0.25 = 0.25$ inch) was found to be 3 pounds. This value changed as the effective specimen length was increased, so that when the separation of the jaws was 5 inches ($l_1 = 5 + 0.25 = 5.25$ inches) it had increased to 8.8 pounds. On this same graph is a plot of calculated tear strength as a function of the effective specimen length for the same fabric used in plot A. Plot B was obtained by calculating the F_t values of equation (13) for various values of l_1. It is seen that the calculated tear strength varies linearly with the effective specimen length. The difference between the two plots is attributed

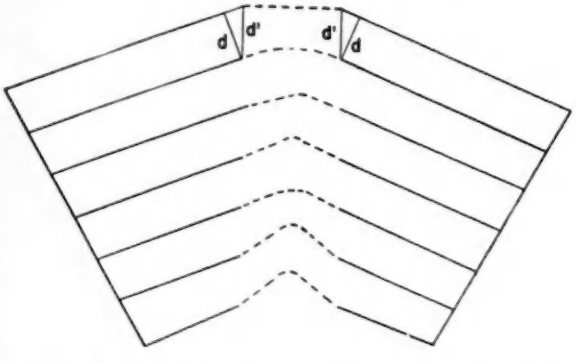

FIG. 3. *Position of the test specimen between the jaws.*

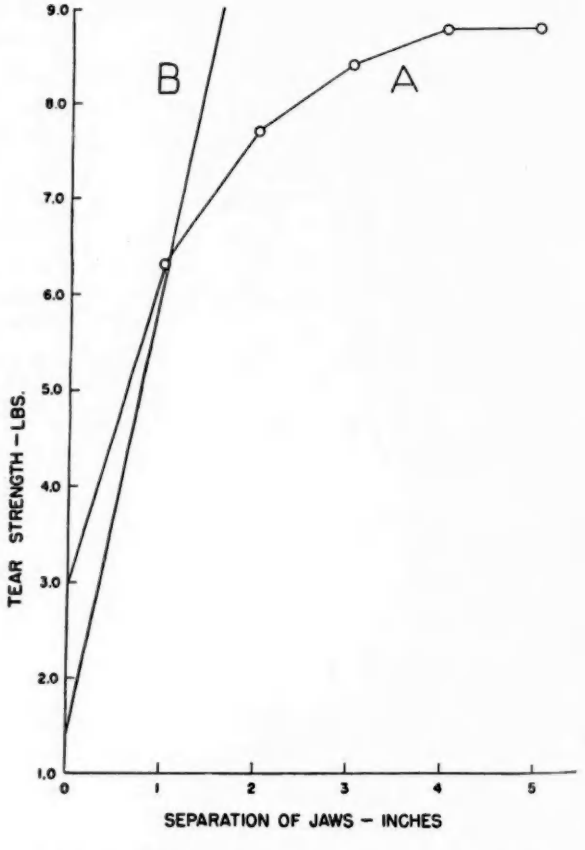

FIG. 4. *Change in tear strength with increased separation of the jaws.*

to the influence of the cross threads, which was discussed above.

The correlation found between the calculated and measured tear strength of the fabrics investigated suggests that the present analytical interpretation of tear strength is essentially a correct one. In spite of the ideal conditions imposed upon the fabrics, the derived equation gives results which are only slightly lower than the observed ones. For practical purposes such an equation can be useful in predicting the tear strength of a fabric from the common load-extensibility diagram for a 1-inch raveled strip.

IV. Summary

An analytical interpretation has been presented on the factors involved in the A.S.T.M. Tear Test. The analysis results in a derived equation which relates tear strength to the extensibility and breaking strength of a fabric. This relationship shows that tear strength is dependent mainly upon the extensibility, breaking strength, and effective specimen length of the threads and the number of threads per inch.

The relationship permits prediction of tear strength of a fabric from the common load-extensibility diagram.

Acknowledgment

The authors wish to acknowledge the work done by Dr. I. J. Gruntfest of this laboratory, who first pointed out the dependence of tear strength on yarn extensibility during the course of an investigation on yarn properties.

Working of the Cotton Card and Its Mathematical Concepts*

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Gladbach-Rheydt Research Institute †

Abstract

The development of a method for the evaluation of carding intensity is traced. The measure suggested for use is the ratio of the number of wire points on the cylinder to the inches of fiber spread on the cylinder (wire points/inch of fiber length). The density of the wire clothing and the fineness of the raw material are considered in the evaluation.

IT is common mill practice today to describe the working intensity of the flat-card in cotton processing by a statement of the number of revolutions per minute of the doffer. This measure is inadequate and does not take into consideration, among other things, the amount of fibers spread over the carding surfaces. It appears practical, therefore, to begin the approach to the problem by determining a function called "combings" and to advance from this by logical steps to the final measure.

Combings

The term "combings" expresses the number of revolutions of the cylinder for 1 inch fed by the feed roll.

For the card gearing shown in Figure 1,

$$C = \frac{(1)(160)(45)(192)(15\frac{1}{2})(7)}{(\pi 2\frac{1}{4})(G_1)(45)(G_2)(4\frac{1}{4})(18)} = \frac{6164}{(G_1)(G_2)} = \frac{K_C}{(G_1)(G_2)},$$

where C is the combings per inch, G_1 is the draft change gear, G_2 is the doffer change gear, and K_C is the combings constant.

As may be observed from the formula, the combings/inch value is inversely proportional to the product of the change gears G_1 and G_2.

TABLE I

Raw material	Combings/Inch
Low-grade cotton	10–15
Medium-grade cotton	15–20
Long-staple cotton	20–30
Synthetic staple fibers	15–20

The range of combings values for different raw materials is shown in Table I.

Spreading

Spreading * is the ratio of the surface speed of the cylinder to the surface speed of the feed roll, or the draft between these two working members. Its value may be obtained from the preceding analysis by multiplying the combings by the circumference of the cylinder.

$$s = (C)(\pi D) = \frac{K_C(\pi D)}{(G_1)(G_2)},$$

where s is the spreading and D is the diameter of the cylinder in inches.

The cylinder diameter shown in Figure 1 is 50 inches; therefore

$$s = \frac{(6164)(\pi 50)}{(G_1)(G_2)} = \frac{968{,}200}{(G_1)(G_2)} = \frac{K_s}{(G_1)(G_2)},$$

where K_s is the spreading constant.

Combings and spreading give comparable measurement for any one card because the card clothing, and therefore the density of the wires, is constant. A practical comparison of carding intensity for ma-

* The original manuscript by Dr. Oeser, in German, was given to Herbert F. Schiefer and Richard T. Kropf, investigators for the Technical Industrial Intelligence Committee, during their mission to Germany in 1945, with the request that arrangement be made for publication in the United States. It was translated from the German by John F. Krasny of the National Bureau of Standards and edited by John F. Bogdan, Professor of Applied Research, North Carolina State College School of Textiles.

† At present at Bönnigheim, Württemberg.

* See "Staple Fiber and Cotton Spinning," by Prof. Ing. Otto Johannsen (source unknown).

chines with varying densities of wire can be made by calculating the number of wires per square inch of drawn-in lap.

Wire Points per Square Inch of Drawn-In Lap

If d is the number of wire points per square inch of clothing, the number of wire points per square inch of drawn-in lap can be obtained by multiplying d by the spreading or draft value s.

$$S = (s)(d) = \frac{(K_C)(\pi D)(d)}{(G_1)(G_2)},$$

where S is the number of wire points per square inch of drawn-in lap.

Wire Points per Ounce of Lap

The effect of lap weight may be considered by determining the number of wire points per ounce of lap.

If at a cylinder width w the weight of the lap in ounces per yard is Z, 1 square inch of lap weight in ounces is P, and

$$P = \frac{Z}{(w)(36)}.$$

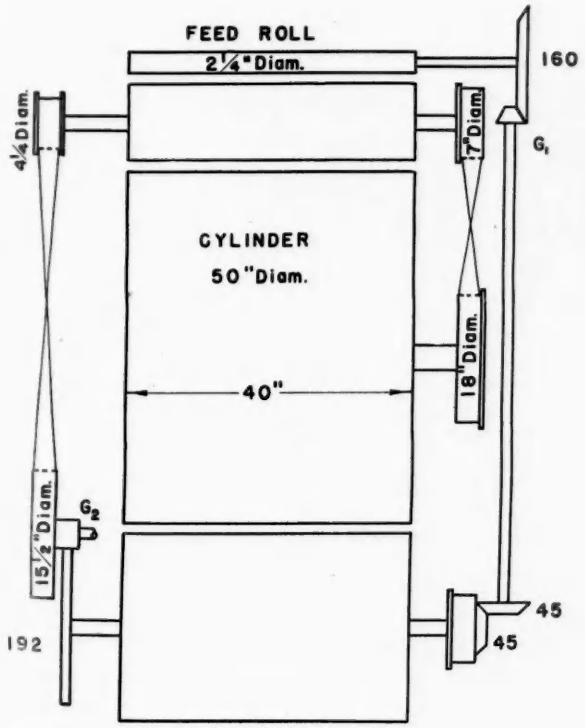

FIG. 1. *Gearing diagram of cotton card.*

The number of wires (N) per ounce of lap,

$$N = \frac{S}{P} = \frac{(K_C)(\pi D)(d)(w)(36)}{(G_1)(G_2)(Z)}.$$

Number of Fibers per Square Inch of Lap

With a fiber weight of u micrograms per inch, and an average fiber length of L inches, the average weight of one fiber in micrograms (M) is

$$M = (u)(L).$$

With the weight in ounces of 1 square inch of lap (P) known, the number of fibers per square inch of lap (n) can be found from

$$n = \frac{(P)(28.35 \times 10^6)}{M} = \frac{(Z)(28.35 \times 10^6)}{(w)(36)(u)(L)} = \frac{(Z)(787{,}500)}{(w)(u)(L)}.$$

Number of Wire Points per Fiber

The intensity of carding expressed as the number of wire points on the cylinder per fiber (I_f) is obtained from the expression:

$$I_f = \frac{S}{n} = \frac{(K_C)(\pi D)(d)(w)(u)(L)}{(G_1)(G_2)(Z)(787{,}500)}.$$

In this formula the following are constant for a particular machine: combings constant, K_C; cylinder circumference, πD; width of cylinder in inches, w; wire points/square inch, d; the conversion factor, 787,500.

The above factors can be incorporated into an "intensity constant" (K_I); all other values are variables.

In Figure 1 the cylinder diameter is 50 inches, cylinder width is 40 inches, the combings constant is 6164, and the card clothing is assumed to be No. 100 ($d = 500$).

Then,

$$I_f = \frac{(6164)(\pi 50)(500)(40)(u)(L)}{(G_1)(G_2)(Z)(787{,}500)} = \frac{(24{,}590)(u)(L)}{(G_1)(G_2)(Z)} = \frac{(K_I)(u)(L)}{(G_1)(G_2)(Z)},$$

where K_I is the intensity of carding constant for a particular machine.

If the cotton stock being carded has an average fiber weight, u, of 4.02 micrograms per inch, an average staple length, L, of 1.07 inches, a lap weight, Z, of 14 ounces per yard, a draft change gear, G_1,

TABLE II

English No. of wire clothing	American No. of wire clothing	Wires per square inch	Factor
130	36	650	1.3
120	35	600	1.2
110	34	550	1.1
100	33	500	1.0
90	32	450	0.9
80	31	400	0.8
70	30	350	0.7
60	28	300	0.6

of 20 teeth, and a doffer change gear, G_2, of 25 teeth, the intensity of carding,

$$I_f = \frac{(24{,}590)(4.02)(1.07)}{(20)(25)(14)} = 15.1 \text{ wires per fiber.}$$

The combings value under the same conditions is

$$C = \frac{6164}{(G_1)(G_2)} = \frac{6164}{(20)(25)} = 12.3/\text{inch.}$$

In carding a 3-denier ($u = 8.47$) synthetic staple fiber with average length $L = 1\frac{1}{2}$ inches, and using the same gearing and lap weights as in the above example,

$$I_f = \frac{(24{,}590)(8.47)(1.5)}{(20)(25)(14)} = 44.6 \text{ wires per fiber.}$$

The combings value would be unchanged from that of the cotton: 12.3 per inch.

Wire Points per Inch of Fiber Length

Although the combings value is unchanged, the intensity of carding of the synthetic staple fiber seems considerably greater than that for the cotton. Since the staple lengths are different in the two examples chosen, this intensity of carding does not give a clear basis for comparison. The relationship can be made comparable by expressing the number of wire points per 1 inch length of fiber (I).

The final formula for carding intensity after eliminating fiber length, L, by giving it a value of unity is

$$I = \frac{(24{,}590)(u)}{(G_1)(G_2)(Z)}.$$

For the foregoing examples:

Cotton: $I = \frac{15.1}{1.07} = 14.1$ wires/inch of fiber length.

Synthetic staple: $I = \frac{44.6}{1.5} = 29.7$ wires/inch of fiber length.

When using card clothing other than No. 100, the above values would need to be multiplied by the appropriate factor in Table II.

For example, if the card in our example has No. 110 card clothing, the intensity of carding constant (K_I) would be multiplied by 1.1.

$$K_I = (24{,}590)(1.1) = 27{,}050.$$

General Formula

The generally applicable formula for any card as derived from the foregoing equalities is:

$$I = \frac{(K_C)(\pi D)(d)(w)(u)}{(G_1)(G_2)(Z)(787{,}500)} = \frac{(s)(d)(w)(u)}{(Z)(787{,}500)},$$

where K_C is the combings constant, πD is the cylinder circumference in inches, d is the number of points of wire clothing/square inch, w is the width of the cylinder in inches, u is the average weight of the fiber in micrograms per inch, G_1 is the draft change gear, G_2 is the doffer change gear, Z is the lap weight in ounces/yard, 787,500 is a conversion factor, and s is the draft between the cylinder and the feed roll.

Substituting the values given originally as examples for cotton and synthetic staple fibers, as a check:

Cotton: $I = \frac{(6164)(\pi 50)(500)(40)(4.02)}{(20)(25)(14)(787{,}500)} = 14.1$ wire points/ inch of fiber.

Synthetic staple: $I = \frac{(6164)(\pi 50)(500)(40)(8.47)}{(20)(50)(14)(787{,}500)} = 29.7$ wire points/inch of fiber.*

* EDITOR'S NOTE: Linear dimensions and weights were shown in metric units in the original manuscript. Conversion to units in use in American mills was undertaken by Prof. Bogdan to make the information more readily available. The diagram (Figure 1) was changed to represent an American machine rather than a European one. Except for these changes, the author's work and method of presentation was followed diligently.

ABSTRACTS

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A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications is given on page 37 of the January, 1947, issue.

ANALYSIS: TESTING: LABORATORY METHODS

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Air Permeability

The Apermeter. A new air-permeability determination apparatus. J. H. Skinkle and A. J. Moreau. *Am. Dyestuff Reptr.* **36**, 245–6 (May 5, 1947).

An apparatus (called an Apermeter) for the measurement of air permeability, which depends essentially upon the determination of the resistance offered by the test fabric to the displacement by water of a definite volume of air, expressed as the time of flow for this volume, is described. A series of 25 fabrics representing a wide range of fiber and fabric construction were tested on the Apermeter and on the Frazier air-permeability apparatus. The average variation of the 25 samples was 8.1% for the Frazier and 0.46% for the Apermeter. Correlation between the 2 instruments, as shown by the Kendall coefficient, is 87%. The Apermeter can be built for about $5.00. K. S. Campbell

Text. Research J. July 1947

Orientation in Natural Cellulose

The submicroscopic structure of the plant cell wall. Otto Treitel. *J. Colloid Sci.* **2**, 237–46 (Apr. 1947).

When rubber is cooled with liquid air and then struck with a hammer, well-oriented rubber (stretched) breaks up into fibers whereas undeformed rubber gives an amorphous powder. This method showed that petioles of *Nymphaea*, which have the low ratio of moduli of elasticity of 3, consist mainly of amorphous cellulose, whereas woody branches of *Salix babylonica*, which have the high ratio of moduli of elasticity of 33, consist mainly of micellar cellulose. The physical behavior of different portions of plant tissue is related to their extent of orientation.

Text. Research J. July 1947 E. D. Klug

Drafting

An instrument for the measurement of the forces operating between fibres during drafting. J. G. Martindale. *J. Text. Inst.* **38**, T151–66 (Mar. 1947).

Earlier papers have dealt with methods of investigating the drafting of cotton by measuring the amplitude and wave length of the drafting wave and the amount of irregularity produced by drafting. In this paper another method of investigation, the measurement of drafting force, is described. The chief object of the paper is to describe the apparatus, which consists of a small draw-frame, the front rollers of which are held in a spring-mounted cradle so that the deflections of the cradle indicate the forces required to effect the drafting of the sliver or roving being passed through the frame. The results of some preliminary measurements on slivers are also given. It is found that photographic records of drafting force are very similar in form to those of the thickness of drafter sliver. They show a wavelike variation in drafting force, which is similar in wave length and amplitude to that previously observed in the records of thickness. As would be expected, the mean drafting force depends greatly on the openness of the sliver which is of the order of 100 g. for a 0.2-hank card silver at a draft of 5 and about a quarter of this for a similar third-head draw-frame sliver. For a given sliver it varies inversely as the draft and is

independent of the speed of drafting. It decreases as the roller setting is increased. As this decrease is related to the fiber length distribution of the cotton, it is not at present possible to relate the drafting forces of different cottons to the frictional or surface properties of the fibers unless the cottons have nearly identical fiber length distributions. One such comparison, between Tanguis and Sakel cottons, is made in the paper. Further work may perhaps make it possible to determine equivalent roller settings for cottons of different length distributions. Attention is directed also to the recording camera used with the apparatus. This is of simple design and may be useful on other pieces of apparatus where photographic recording is required. Author

Text. Research J. July 1947

Flame-Resistance

Composition and function of flame-resistant treatments for textiles. R. W. Little. *Am. Dyestuff Reptr.* **36**, P135–9 (Mar. 24, 1947).

Terms relating to flameproofed textiles are carefully defined and testing procedures are critically discussed. Present theories accounting for the flame-retarding activity of various agents are described and the methods of application of these agents are reviewed. The principal function of a fire-retardant seems to be the reduction of the amount of dry, highly inflammable tars formed during the thermal degradation of cellulose. For a fabric to exhibit no after-flaming (following application of a test flame) the tar formation must be held to less than 2 mg. per sq. cm. of fabric. Efficient retardants which reduce tar formation by the required amount bring about a corresponding increase in the amount of solid char formed. In the most recently developed approach to durable flameproofing the cellulose molecule is modified to form the cellulose phosphate ester or a suitable amido salt of this acid ester. The latter product shows increased resistance to ionic exchange phenomena (during bleaching or laundering). The degree of strength loss incurred by the fabric during this treatment depends upon the curing conditions employed, which in turn influence the over-all permanence of the treatment. It is pointed out that since flameproofing mechanisms are for the most part chemical reactions, each chemically different fiber type must be considered as a separate problem.

K. S. Campbell

Text. Research J. July 1947

Soap Hydrolysis and Detergency

The influence of soap hydrolysis on detergent action. K. Tomlinson. *J. Soc. Dyers and Colourists* **63**, 107–9 (Apr. 1947).

It has been shown that a minimum of detergent power of soap solution exists at a concentration corresponding approximately to that of maximum soap hydrolysis. (At such a concentration there will be formed acid soaps which will precipitate and be absorbed by the fabric being washed; this will prevent the removal of underlying soil material and also decrease the detergent molecules in solution.) This minimum can be removed by adding substances which will suppress soap hydrolysis. The effect of adding sodium carbonate to the solution is discussed. Author

Text. Research J. July 1947

Measurement of Dye Strength

The accuracy of colorimetric instruments in dye-strength determinations. O. L. Davies, C. H. Giles, and T. Vickerstaff. *J. Soc. Dyers and Colourists* **63**, 80–3 (Mar. 1947).

A statistical examination is described of the results of a series of dye-strength determinations with typical colorimetric instruments, made by 6 observers, each using 5 acid dyes which substantially covered the visible spectrum and which were employed in 4 strengths of solution. Of the instruments examined, the photoelectric absorptiometer is the most accurate, with an over-all mean standard error of 1.00%, compared with 1.35% for the visual spectrophotometer and 2.49% for a Duboscq-type colorimeter. This last instrument gave the least consistent results, ranging from a mean standard error of 0.85% for a blue dye to one of 5.47% for a yellow dye. The accuracy of the results given by the photoelectric absorptiometer is independent of the color-matching experience of the operator, whereas that of the other 2 instruments is dependent on such experience.

Text. Research J. July 1947 Authors

Fluidity Measurements

Improved equipment and methods for fluidity measurements of cellulose and cellulose acetate. D. S. Lyle and F. K. Ray. *Am. Dyestuff Reptr.* **36**, 123–7 (Mar. 10, 1947).

An improved mixing device for the dispersion of cellulose in cuprammonium solutions and cellulose acetate in acetone, and a constant temperature bath built to accommodate 20 mixing vials and 7 pipette viscometers, are described. Details of construction of the apparatus and technique of making the determinations are given. 40 measurements can be made daily. K. S. Campbell

Text. Research J. July 1947

Staple Length Measurement

A photoelectric method for measuring the staple length of cotton. E. Lord. *J. Text. Inst.* **37**, T237–59 (Nov. 1946).

Light reflected from a tuft of fibers at an angle of 45° falls on a photocell connected with a galvanometer. The current varies as the visual density at the illuminated portion

of the tuft. By moving the stage with a screw arrangement, determinations of density can be made at equal intervals along the tuft. The successive differences in galvanometer readings are plotted against the position of the stage at the midpoint of the interval. A curve is obtained that exhibits two maxima. The distance between the maxima is taken as the modal staple length. Excellent correlation was obtained between the nominal lengths of official U. S. standards and measurements by this method. The method is rapid and suitable for routine mill use. A. R. Martin

Text. Research J. July 1947

Plastic Zone of Nylon

The initiation and propagation of the plastic zone along a tension specimen of nylon. Julius Miklowitz. *J. Colloid Sci.* **2**, 193–215 (Feb. 1947).

The effects of the speed of stretching and the rigidity of the testing machine on the initiation and propagation of the plastic zone and the accompanying phenomenon are studied. E. D. Klug

Text. Research J. July 1947

Stress-Strain Properties of Nylon

The stress-strain relationship of nylon under biaxial stress conditions. Julius Miklowitz. *J. Colloid Sci.* **2**, 217–22 (Feb. 1947).

In a previous paper the writer describes and discusses the stress-strain characteristics of nylon, under an applied-uniaxial tensile stress. The present paper describes a method by which the stress-strain characteristics of nylon under equibiaxial tensile stress were investigated. The results of the tests made are used for comparison with the applied single-stress condition, under which nylon shows a well-defined yield point and localized yielding. Author

Text. Research J. July 1947

Viscoelastic Properties

Viscoelastic properties of thermoplastics at elevated temperatures. G. J. Dienes. *J. Colloid Sci.* **2**, 131–61 (Feb. 1947).

A method of measurement and analysis, based on the parallel plate plastometer, was developed for the determination of the viscoelastic properties of plastic materials at elevated temperatures. The method was applied to vinyl chloride-acetate resin, polyethylene resin, and a cellulose acetate butyrate plastic. The data show that the deformation is proportional to the applied stress. The viscoelastic properties at elevated temperatures may be represented by a simple mechanical model. The variation of viscoelastic constants with temperature and composition was evaluated. The effect of increasing the molecular weights of polyethylenes is to increase the resistance to both the elastic and viscous types of deformation. E. D. Klug

Text. Research J. July 1947

Bingham Viscometer

The Bingham viscometer and viscosity standards. J. F. Swindells. *J. Colloid Sci.* **2**, 177–84 (Feb. 1947).

The technique used with variable-pressure viscometers of the Bingham type for evaluating the viscosities of standard viscosity samples of the National Bureau of Standards is described. Corrections for various sources of error are given.

Text. Research J. July 1947 E. D. Klug

Testing Water-Repellence

A correlation of water-repellent garment performance and laboratory penetration tests on fabrics. G. A. Slowinske and A. G. Pope. *Am. Dyestuff Reptr.* **36**, P108–21 (Mar. 10, 1947).

Of 5 laboratory penetration testers studied, the rain tester (essentially a device for testing the penetration-resistance of fabrics by the use of different intensities of water impact) appears to be the most versatile. The rain-room data indicated that the relative performances of a series of water-repellent raincoats may change as the rain intensity varies. The Bundesmann and drop-penetration testers employ water drops impinging on the test fabric with a single intensity, and thus do not take into account the fact that natural rains vary in intensity. The hydrostatic pressure tester does not simulate the dynamic effects of rain, and, therefore, could not be expected to indicate the probable performance of garments in general. The impact penetration tester employs a single intensity of water impact, and thus suffers from the same fault as the Bundesmann and drop-penetration testers. However, it is believed that the impact penetration test, because of its simplicity and ease of operation, is suitable for ruling out fabrics of limited water-repellency. The inclusion of absorbent thread or trimming fabrics in rainwear results in a serious decrease in the protection afforded by the garment. It is believed that such garments should be unlined or that linings should be water-repellent. Doubling a fabric will markedly improve its performance. However, the garments tested showed that some consideration should be given to the single-thickness properties of fabrics to be used in double-thickness rainwear. For example, the use of an inadequate outer shell will allow rain to pass through the first layer and into the pockets. Authors

Text. Research J. July 1947

Wetting of Textiles

Speed of wetting of textile materials. The use of a hydrometer method. I. J. Gruntfest, O. B. Hager, and H. B. Wilson. *Am. Dyestuff Reptr.* **36**, 225–6, 252 (May 5, 1947).

Studies of the rate of wetting of textiles using a specially designed hydrometer to which yarn or fabric could be attached and its buoyancy thereby measured, brought out the

fact that solutions of wetting agents which show short Draves sinking times do not wet the material as completely as solutions which show longer sinking times. Each of many wetting agent solutions tested showed this effect, viz., the crossing of the time-buoyancy curves for increasing dilutions of the same agent. Gray cotton yarn, for example, was, after 100 seconds, more completely wetted by a 0.02% solution of wetting agent than by a 0.05% solution of the same agent. One implication of this finding is that in selection of the most appropriate wetting solution for a given process the degree of wetness necessary to ensure the success of the process must be considered.

K. S. Campbell

Text. Research J. July 1947

CHEMICAL AND PHYSICAL RESEARCH

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Fundamentals of Adhesion

The fundamentals of tackiness and adhesion. J. J. Bikerman. *J. Colloid Sci.* **2**, 163–75 (Feb. 1947).

The effectiveness of an adhesive (usually a liquid) in causing two solids to adhere depends on the wetting power of the adhesive. This is primarily a "molecular" phenomenon. The resistance which must be overcome to separate the two solids is tackiness. Its mechanism is purely rheological and tackiness is a function of viscosity. When an adhesive is setting, the viscosity becomes very high. Resistance to separation is then lower than would be expected from the viscosity. New data in the region of setting are reported. After an adhesive has set, the strength of the bond is identical with the tensile strength of the film. The rupture usually occurs within the set adhesive, not between the adhesive and the solid. The final strength, therefore, is also a rheological property.

E. D. Klug

Text. Research J. July 1947

Precipitation of Cations

The pH value for precipitating various cations, and a law for their precipitation. III. Cesare Bordoni. *Ann. chim. applicata* **34**, 11–17 (1944); cf. *C.A.* **38**, 5469[8] (through *Chem. Abstr.* **41**, 2631*b* (May 10, 1947)).

Precipitation of OH does not take place at a definite pH but within a range of pH values. All OH compounds start to precipitate at a pH characteristic for each metal, but as the concentration of OH decreases this value approaches pH 3.73. All alkaline salts of acids whose dissociation constant is greater than pH 3.73 hydrolyze in neutral solution in the presence of these salts, precipitating the corresponding hydroxide.

Text. Research J. July 1947

Chemistry of Cellulose

The chemistry of cellulose. L. Denivelle. *Papier* **47**, 161–2, 165–72, 175 (1944) (through *Chem. Abstr.* **41**, 2573*a* (Apr. 20, 1947)).

A review outlines the results of investigations on the constitution of cellulose up to and including the investigations of Freudenberg. However, no specific references or new data are given.

Text. Research J. July 1947

Optical Properties of Cellulose

System cellulose-water. III. Dependence of the optical properties of cellulose fibers on their water content. P. H. Hermans, J. J. Hermans, and D. Vermaas. *Kolloid-Z.* **109**, 86–90 (1944); cf. *C.A.* **40**, 201[7] (through *Chem. Abstr.* **41**, 3291*e* (May 20, 1947)).

The influence of the moisture content on the 2 *ns* and on the double refraction of cellulose fibers can be evaluated quantitatively by the same simple equation developed for the effect of moisture on the refractive capacity of isotropic cellulose fibers. Since this equation presents a simple application of the rule to mixtures of 2 components, the results confirm the new concept that the H_2O is distributed homogeneously in the amorphous fiber (forming a single phase), and not heterogeneously in accordance with the classical Nägeli hypothesis. The relationship of this concept to the Wiener theory of the optics of mixed substances is discussed. Good agreement was obtained between the physical behavior of the cellulose-water systems and those of much simpler binary systems, such as H_2SO_4-H_2O.

Text. Research J. July 1947

Penetration of Water into Cellulose

Velocity of penetration of water and glycerol in cellulose threads. P. H. Hermans and D. Vermaas. *Kolloid-Z.* **109**, 5–9 (1944) (through *Chem. Abstr.* **41**, 3291*g* (May 20, 1947)).

The absorption of H_2O by dry cellulose fibers can be observed easily by optical means. After a time a sharply defined line can be detected along the periphery of the fiber; this indicates the distance penetrated by the H_2O. In absolutely dry cellulose, H_2O penetrates very slowly. In cellulose which contains some moisture, the diffusion velocity increases with the 4th or 5th power of the equilibrium moisture in the fiber. With fibers containing less than 15% H_2O, a temperature coefficient of 2.4, similar to that of a chemical reaction, is obtained. This indicates the possibility of chemical reaction of the H_2O with the cellulose. Glycerol penetrates the cellulose fiber only when the latter is in equilibrium with a relative humidity of at least 40%. Dry cellulose is impenetrable to indifferent liquids. These phenomena are analogous to the diffusion of H_2O into certain zeolites.

Text. Research J. July 1947

Xanthation of Cellulose

The reaction between alkali cellulose and carbon disulfide. Olof Samuelson. *Svensk Kem. Tid.* **58**, 285–93 (1946) (in English) (through *Chem. Abstr.* **41**, 3292*f* (May 20, 1947)).

NaOH bound in the cellulose crystallites reacts quickly with CO_2. When alkali cellulose is treated with an excess CS_2 for a long period, the crystallites will disappear. The crystallites cannot be of any essential hindrance to the xanthation even in a short time and with small quantities of CS_2. The reaction between NaOH and CS_2 takes a much longer time than that with CO_2. During xanthation a shell of xanthate gel is formed, impeding uniform xanthation. In experiments with low-pressure ratios (2.4, 2.8), where the xanthated cellulose had been treated for a minute with CO_2, there was no NaOH remaining but with high-pressure ratios (3.0, 3.5), the NaOH does not react quantitatively with the CO_2. Viscosity and filter values (Hermans, Bredee, and Booys, *C.A.* **29**, 3801[6]) increase with the pressure ratio. Some of the filtration difficulty is due to the increase in side reactions; the consumption of NaOH increases with increasing pressure ratio.

Text. Research J. July 1947

Density of Cellulosic Fibers

Density and refractivity of cellulose fibers. P. H. Hermans, J. J. Hermans, and D. Vermaas. *Kolloid-Z.* **109**, 9–16 (1944); cf. *C.A.* **40**, 5255[5,8] (through *Chem. Abstr.* **41**, 3291*b* (May 20, 1947)).

The usual concept that, in determining the density of cellulose in various media, the porosity of the cellulose fiber must be taken into account, may be given up. The best interpretable density values are obtained with liquids which do not penetrate the fiber substance. It is doubted that the density values obtained in the He voluminometer are the true values. The density measurements of natural (bleached cotton, standard cotton, α-pulp, Bemberg rayon) and synthetic (viscose) fibers in CCl_4 were correlated with the refractive properties of these fibers (in a mixture of Bu stearate and tritolyl phosphate). The methods of determining the density and index of refraction of these celluloses are described in detail. The density values are reproducible within 0.5%. The molecular refractivities calculated from the observed data agree well with the value for $C_6H_{12}O_5$ calculated from the atomic refractivities for organic compounds. By reducing the density values of various fibers to equality, it is possible to compare the optical constants of these fibers on a rational basis. There is close relationship between the density, percentage crystalline material, and sorption capacity of the fiber for H_2O.

Text. Research J. July 1947

Viscosity of Cellulose Acetate

Viscosities of solutions of cellulose acetate in solvent-precipitant mixtures. S. G. Weissberg and Robert Simha. *J. Colloid Sci.* **2**, 305–6 (Apr. 1947).

Viscosities of solutions of cellulose acetate fractions (mol. wt. 110,000, 53,000, and 24,000) in acetone-methanol mixture were measured at 10°C, 25°C, and 35°C. The solvent composition varied from pure acetone to 60 vol.-% methanol (almost the precipitation point). For solvent mixture containing up to 50% methanol, the intrinsic viscosities are almost constant. Further additions of methanol cause sharp decreases in intrinsic viscosity. The relative change is largest for the lowest-molecular-weight fraction. The limiting slope of plots of $\eta sp./C$ vs. C increases with increasing methanol content for the lowest mol. wt. fraction; in the higher ones, this increase is only pronounced above 50% methanol. The temperature coefficients of intrinsic viscosity are all negative and become less negative at higher methanol concentrations. The absolute values of these coefficients increase with molecular weight. E. D. Klug

Text. Research J. July 1947

Molecular Properties of Nitrocellulose

Molecular properties of nitrocellulose. George J. Doyle, Garman Harbottle, Richard M. Badger, and Richard M. Noyes. *J. Phys. & Colloid Chem.* **51**, 569–74 (Mar. 1947).

Measurements of viscosity have been made on dilute solutions of several nitrocelluloses in acetone and in butyl acetate, and it has been found that the results can be expressed by an equation of the form

$$\eta_{rel} = 1 + [\eta]c \times 10^{k[\eta]c}$$

in which η_{rel} is the relative viscosity of solution, $[\eta]$ is the intrinsic viscosity of the solute, and c is the concentration in grams per 100 ml. The constant k is approximately 0.2 for both acetone and butyl acetate and appears to vary for different preparations of solvent. The ratio of the intrinsic viscosities in butyl acetate and in acetone is about 1.40 for nitrocelluloses having intrinsic viscosities greater than about 1, but the value of the ratio appears to fall off for low-viscosity nitrocelluloses. The value of this ratio appears to vary for different preparations of solvents but is constant within about ±0.004 for measurements made with specific preparations. Authors

Text. Research J. July 1947

Molecular properties of nitrocellulose. II. Robert H. Blaker, Richard M. Badger, and Richard M. Noyes. *J. Phys. & Colloid Chem.* **51**, 574–79 (Mar. 1947).

The absolute value of the Staudinger constant for nitrocellulose in acetone has been determined by means of measurements of osmotic pressure and of viscosity and by the use of data previously reported in the literature. Measurements of number-average and weight-average molecular weights on 6 commercial nitrocelluloses indicate that materials prepared from wood pulp are distinctly more heterogeneous molecularly than those prepared from cotton linters. Authors

Text. Research J. July 1947

Keratin

Some biological and chemical properties of animal hair. J. L. Stoves. *J. Soc. Dyers and Colourists* **63**, 65–77 (Mar. 1947).

The processes of histogenesis (with reference to hair development) are described, and the significance of nutritional factors such as protein intake, action of hormones, vitamins, and trace elements is discussed. Pigmentation of hair is considered from the biological and chemical standpoints. The cellular and macromolecular structure of hair is reviewed. Photomicrographs are given, illustrating various aspects of the growth and structure of animal hair. Changes in the physico-chemical properties of human-hair fibers have been used to study the chemical action of alkalies, oxidizing agents, formaldehyde, quinones, and enzymes on keratin. Further experimental data are adduced for the view that alkalies act upon the cystine linkage of keratin to form linkages of the type

$$\begin{array}{ccccc} | & | & | & & \\ -C-S-C- & \text{and} & -N=CH-, & & \\ | & | & | & & \end{array}$$

whereas Millon's reagent is shown to give rise to new linkages which are ruptured by boiling water. Studies of the reaction of hair with formaldehyde solutions of pH 1 at 100°C are described, and evidence is brought forward pointing to the formation of two types of new linkage which are stable to boiling solutions of sodium metabisulfite. One type is hydrolyzed by boiling 0.1 *N* phosphoric acid, while the other is stable to such treatment. It is suggested that the former linkage probably arises by reaction of formaldehyde with amide groups while the stable type is of the djenkolic acid form. The effect of various quinones on the stress-strain diagrams and supercontraction in bisulfite of human hair are described and the probable nature of the reactions is discussed. Enzymolysis of keratin fibers is considered, and photomicrographs are shown illustrating the degradation of wool by *B. subtilis*. Studies of axial contraction of keratin fibers in sodium metabisulfite, thioglycollic acid, formic acid, chlorine water, cuprammonium hydroxide, urea and *m*-cresol are described. Author

Text. Research J. July 1947

Keratin Fibers

Structure and elasticity of the cortex of keratin fibers. An electron microscope study. E. H. Mercer and A. L. G. Rees. *Australian J. Exptl. Biol. Med. Sci.* **24**, 175–83 (1946); cf. *C.A.* **40**, 7639[6], 4527[5] (through *Chem. Abstr.* **41**, 3300*g* (May 20, 1947)).

An electron microscopic study of fragments derived from the cortex of wool fibers by enzymic and mechanical disintegration reveals the presence of two main components, (1) a fibrillar, and (2) an amorphous matrix. Some observations on the extensibility of these components have been possible. The solid matrix appears to pass under stress from a rigid solid into a viscous sol, but gels again when the stress is removed. Under stress in the sol form, the material may be distorted and drawn out into threads in a manner that resembles the behavior of a viscous rubber solution. The sequence of events during the stretching of wool is: (1) The fiber extends as a rigid body (Hookes' Law) up to 2%. (2) At 2% the yield point of the intercellular and intra-fibrillar gel is reached and flow occurs in this phase. (3) Beyond 20% both fibrils and the matrix are stretched together with an increasing resistance to extension developing owing to the greater yield value of the fibrils. The 40% extension of the fibrils may be effected by the unfolding of the polypeptide molecular chains. The change from gel to sol of the matrix is assumed to be produced by the rupture of linkages such as the salt and disulfide. Their reformation converts the sol to a gel again giving rise to the phenomenon of "set."

Text. Research J. July 1947

Sulfonation of Napthalene

A theoretical discussion of positional sulfonation of naphthalene and of some of its derivatives. Part II. α- and β-naphthols, α- and β-naphthylamines, and their common monosulfonic acids. H. Hodgson and D. E. Hathway. *J. Soc. Dyers and Colourists* 63, 109–12 (Apr. 1947).

The interpretation already given in Part I (*J.S.D.C.* **63**, 46, 1947) of data on the sulfonation of naphthalene is now extended to the sulfonation of its monohydroxy- and its monoamino- derivatives and of their common monosulfonic acids. The sulfamic acid intermediate theory of Bamberger, recently modified and amplified by Alexander, has been adopted and, together with the aid of the resonance theory discussed in Part I, which indicates the activated or deactivated positions of the naphthalene nucleus, a logical explanation of the mass of data extant is provided. Authors

Text. Research J. July 1947

Effect of pH on Wool

Measurement of damage in wool materials. Part III—The degree of modification produced by treating wool fabrics with buffered acid and alkaline solutions. C. S. Whewell and D. M. Bee. *J. Soc. Dyers and Colourists*, **62**, 178–80 (June 1946).

Measurements are made of the resistance to wet abrasion of patterns of light-weight flannel which have been treated at various temperatures with buffered solutions of pH 1–12. The results show that the degree of modification increases with rise of temperature, and at a fixed temperature the reduction in resistance to abrasion depends on the pH of the liquid with which the cloth has been treated, being a minimum in the region of pH 4–7. The presence of residual acid or alkali reduces the resistance of fabrics to wet abrasion. The degree of modification produced by blowing at various pH values increases with increasing acidity or

alkalinity, outside the region pH 5–7. Whenever possible, processing should be carried out at pH 5–7.

Text. Research J. July 1947 Authors

Crystal Formation in High Polymers

Mixed crystal formation in high polymers. C. W. Bunn and H. S. Peiser. *Nature* **159**, 161–2 (Feb. 1947).

Conclusions are drawn from studies of examples of isomorphous replacement in crystals of long-chain molecules. Three implications are suggested: (1) in polyvinyl alcohol, the hydroxyl groups might be randomly placed in the alternative space positions on either side of the plane of the carbon chain; (2) when substituent groups are similar in size and shape, molecules which are chemically irregular may be nearly enough geometrically regular to crystallize; and (3) even in crystals of chemically regular polymers, the molecules of which can be geometrically regular, different configurations of monomer units obtainable by rotation around single bonds might occur, providing that the energy contents and the effective external shapes of the alternative configurations are similar. R. W. Eyler

Text. Research J. July 1947

Viscosity of Polymers

The influence of solvent composition on the specific viscosities of polymer solutions. Turner Alfrey. *J. Colloid Sci.* **2**, 99–116 (Feb. 1947).

The intrinsic viscosityof polystyrene is high in "good" solvents and low in "poor" solvents. In the equation $\eta sp = [\eta]C + K^1[\eta]^2C^2$, K^1 is higher in poor solvents than in good solvents. In a poor solvent, an increase in temperature results in an increase in intrinsic viscosity, whereas in an energetically indifferent solvent, the intrinsic viscosity is practically independent of the temperature. This is explained in terms of curling, agglomeration, etc. Other similar materials considered are polyisobutylene and polyvinyl chloride. Polymeric materials which have rigid chains or which possess different kinds of chemical groups distributed on the chain behave differently. No new data. E. D. Klug

Text. Research J. July 1947

Viscosity of Polystyrene

Concentrated solution viscosity of polystyrene. R. S. Spencer and J. L. Williams. *J. Colloid Sci.* **2**, 117–29 (Feb. 1947).

Data on the viscosity of polystyrene solutions in concentrations up to 50% by weight of polymer are presented. Martin's equation holds up to concentrations of 20% polymer. A linear relationship exists over the whole range between the logarithm of the viscosity and (1) the square root of the weight fraction of polymer, (2) square root of molecular weight, and (3) reciprocal of absolute temperature (all conditions not being considered as constant). It is suggested that the relationship of activation energy of flow to concentration is a good method of studying interaction of polymer and solvent. Extrapolation to obtain the activation energy of flow of pure polystyrene using data of different workers is discussed. It is concluded that the correct value is approximately 12 K cal. E. D. Klug

Text. Research J. July 1947

Test for Cure of Thermosetting Resins

Measurements of cure of some thermosetting resins. Manuel N. Fineman and Ira E. Puddington. *Can. J. Research* **25B**, 101–7 (1947) (through *Chem. Abstr.* **41**, 2931*g* (May 10, 1947)).

The rate and extent of cure of resorcinol-formaldehyde and unsaturated polyester resins were determined by measuring electrical resistance and density during the curing process. Curves of log resistance against time during the curing at room temperature of resorcinol-formaldehyde resins of pH 3.0, 5.5, and 7.0 showed that the slope of the curve and the extent of change of electrical resistance increased very rapidly as the pH of the resin was increased. In the polyester resin, Laminac 4122, adding 0.5% and 0.3% of catalyst and curing at 80°, produced a marked increase in resistance as the resin changed from a liquid of 200 centipoises to a hard solid, then a leveling off; however, resin with 0.1% added catalyst increased in resistance much less with time than the other 2 samples. The density data of the resorcinol-formaldehyde resins showed that the resin of pH 5.0 decreased in volume only to a slightly greater degree than the resin of pH 3.0. The resin of pH 7.0 cured too rapidly to yield accurate results by the dilatometric method used. The density of the Laminac 4122 resin, with 0.1% added catalyst, increased rapidly during the curing at 80°, much more so than the resorcinol resins. Polyesters with 0.3% or higher catalyst concentration shrank too rapidly to yield reliable data. Theoretically, the data were interpreted in terms of a cross-linkage mechanism. With an increase in cross-bonding during curing, the mobility of the ions within the resins was restricted to a greater extent; this caused an increasingly higher resistance until the maximum cross-bonding was affected. Likewise, cross-bonding caused the resin molecules to be more closely oriented and thus progressively to occupy a smaller and smaller volume until the cross-linking was complete.

Text. Research J. July 1947

Vinyl Resins

Vinyl resins. IV. Solutions and the film-forming process. A. V. Blom. *Paint Tech.* **11**, 341–6 (1946); cf. *C.A.* **40**, 7091[9] (through *Chem. Abstr.* **41**, 3305*g* (May 20, 1947)).

Solvent types are classified in order of their polarity as follows: aliphatic

hydrocarbons (nonpolar), aromatic hydrocarbons, ethers and acetals, chlorinated hydrocarbons, ketones and esters, alcohols and water (maximum polarity). For a given type of compound, polarity diminishes with increasing molecular weight. Active, latent, and nonsolvents are discussed. The presence of a latent solvent in a coating composition increases the tolerance of an active solvent for nonsolvents. Owing to the fact that they are loosely held in molecular aggregate groupings, nonsolvents have a greater tendency to evaporate than active solvents of similar vapor pressure. A general survey is presented on the solubility of some common vinyl resins. The mechanism of film formation from a solution is postulated. Unless well-balanced solvent mixtures are present, film defects like pinholing, orange peel, and honeycombing may result. Such defects are starting points for film breakdown. Photographic methods indicate that the force field created by weak spots is a direct cause of checking and cracking. Under polarized light, internal stresses in a cracked film are visible as bright bands all along the cracks.

Text. Research J. July 1947

High Pressure Rheology

The rheological properties of matter under high pressure. P. W. Bridgman. *J. Colloid Sci.* **2**, 7–16 (Feb. 1947).

A review, mainly of the author's work. The effect of very high pressures is to increase the viscosity of liquids. The extent of the increase at 12,000 kg./cm² varies from 30% for mercury to 10^7 times for eugenol. The temperature coefficient of viscosity increases with pressure. The viscosity, at constant volume, is constant up to pressures of a few thousand kg./cm², but above that the viscosity decreases at higher temperatures. The fundamental mechanism of viscosity of liquids is different from that of gases. Expressions for the variation of viscosity with pressure, derived by Eyring and others, agree with the data at pressures as high as 10,000 kg./cm². The behavior of solids changes greatly at high pressures. For example, the ductility of mild steel increased, permitting an elongation under a hydrostatic head pressure of 25,000 kg./cm² of 150 times that at atmospheric pressure. Other rheological properties of solids at high pressures are discussed.

Text. Research J. July 1947 E. D. Klug

Chlorinated Starch

Chlorinated starch. Robert Haller. *Helv. Chim. Acta* **29**, 1688–9 (1946) (in German); cf. *C.A.* **40**, 6857⁹ (through *Chem. Abstr.* **41**, 2921*d* (May 10, 1947)).

The products of reaction of halogens with potato starch (*I*) are adsorption compounds, in which some degradation of the starch has occurred. Cl has a greater degrading action than Br. Thus *I* is shaken at room temperature with saturated Cl-H_2O for several hours, the process repeated with fresh Cl-H_2O and the product isolated as a white powder retaining its original granular structure. The chlorinated starch does not reduce Fehling solution but reduces Ciba Yellow GN in alkaline medium, gives a blue *I* color, has a lowered paste viscosity, and contains some adsorbed Cl.

Text. Research J. July 1947

Conversion of Starch

Kinetics of β-amylase action in 20% starch pastes at elevated temperatures. Walter D. Claus. *Cereal Chem.* **24**, 59–69 (1947) (through *Chem. Abstr.* **41**, 2761*e* (May 10, 1947)).

The conversion of 20% corn starch pastes by β-amylase was studied at pH 5.5 at temperatures between 20° and 69° and at 65° between pH values 4.68 and 6.85. Under these conditions production of maltose takes place according to a zero-order reaction up to about 18% conversion. The enzyme is inactivated exponentially by temperatures above 45°. A mathematical treatment of the conversion curves was applied for the determination of the intrinsic activities of the enzyme and the temperature inactivation indexes. Activity at 65° remained constant over pH range 4.68–6.85, and at 65° inactivation was at a minimum between pH 5.4 and 6.4, increasing on either side. Activity at pH 5.5 increased 8-fold between 20 and 65°, at which temperature it reached a maximum and began to decrease. The temperature coefficient Q_{10} of activity decreased linearly from 2.14 at 25° to 1.0 at 65° and to less than 1.0 at higher temperatures. Temperature inactivation set in at 45° and became greater as temperature increased. The curve showed a sharp rise at about 63–65°, corresponding approximately with the activity maximum.

Text. Research J. July 1947

Starch Consistometer

The flow of starch pastes. Part IV. A new consistometer for starch pastes and some results obtained with it. R. S. Higginbotham. *J. Text. Inst.* **38**, T131–50 (Mar. 1947).

A description of an instrument similar in principle to Caesar's consistometer, but very much more sensitive. The results obtained with it are reproducible to within 1% for pastes of unmodified starches containing 5% or more of starch, and only 170 cc. of paste are used. The power required to stir the paste at constant speed and at constant temperature (usually 99°C) is measured by a mechanical dynamometer which is found to be much more sensitive than an electrical method which was tried first. The cold starch suspension is poured into the stirring vessel, which is surrounded by a bath of water at 99°C. The initial swelling temperature of the starch is reached within 3 min. and the temperature of the bath within 5 min. The consistency of the paste reaches its maximum value quickly, and is falling during most of the period over which observations are made. So far, most of the

work with this instrument has been concerned with the comparison of sizing starches. The conditions selected are severe enough to reproduce fairly well the average industrial conditions of preparation of sizing or other well-gelatinized pastes. No attempt has been made to express the results as apparent viscosities, since the conditions of flow are too complex. Following Caesar and others, the torque (in g.-cm.) to stir the pastes under the given conditions is called the "consistency." A fairly smooth, though nonlinear, relationship is found between the consistencies of pastes after 60 min. and their apparent viscosities measured under a constant stress of 100 dynes/cm². A linear relation is also observed between the consistencies after 60 min. at 99°C of tapioca pastes varying in concentration from 5 to 20% and their apparent viscosities measured at a constant rate of shear of about one reciprocal second in a rotational viscometer, to be described in a later paper. Author

Text. Research J. July 1947

Chloroaminophenol Sulfonic Acids

4-Chloro-2-aminophenol-5- and -6-sulfonic acids, their characterization and differentiation. J. F. Gaunt, F. M. Rowe, and J. B. Speakman. *J. Soc. Dyers and Colourists* **63**, 48–51 (Feb. 1947).

Owing to the similarity in the properties of pairs of dyes made by coupling diazotized 4-chloro-2-aminophenol-5- and -6-sulfonic acids with the same coupling component, the identity of the former compound was open to suspicion. Consequently, 4-chloro-2-aminophenol-5-sulfonic acid has been prepared by sulfonating 5-chlorobenzoxazolone and then hydrolyzing the 5-chloro-benzoxazolone-6-sulfonic acid. 4-chloro-2-aminophenol-5- and -6-sulfonic acids have been characterized by conversion into 5-chlorobenzoxazolone-6- and -7-sulfonic acids, from which the *S*-benzylthiuronium and *p*-toluidine salts were prepared. These derivatives possess satisfactory melting points and are suitable for the identification of 4-chloro-2-aminophenol-5- and -6-sulfonic acids. The preparation of 2-aminophenol-5-sulfonic acid from *o*-aminophenol via benzoxazolone is described, and 2-aminophenol-4- and -5-sulfonic acids are also readily identified by means of their *S*-benzylthiuronium and *p*-toluidine salts. Authors

Text. Research J. July 1947

Swelling

Swelling. E. H. Buchner. *Rec. trav. chim.* **65**, 616–19 (1946) (in English) (through *Chem. Abstr.* **41**, 1910*a* (Apr. 10, 1947)).

Various hypotheses of the phenomenon of swelling are discussed and a new mechanism is proposed. Instead of supposing that the liquid penetrates the gel and pushes the colloidal particles away it is suggested that the colloid spontaneously disperses in the liquid as a result of a limited Brownian movement. The liquid is then retained by capillary forces. The swellability of a substance depends on the solubility of certain parts of the molecules. Substances with unlimited swelling capacity dissolve very slowly because their particles are not everywhere bound with the same intensity. Substances with limited swelling capacity are said to be soluble but the solution velocity is very small. The difference between the 2 groups is therefore ascribed to micellar forces. Consideration is given to the heat of swelling, swelling pressures, and the effect of salts.

Text. Research J. July 1947

Properties of Thickeners

Deformation properties of thickeners (for calico printing). M. G. Shikher. *J. Applied Chem. (U.S.S.R.)* **19**, 542–52 (1946) (in Russian) (through *Chem. Abstr.* **41**, 2582*f* (Apr. 20, 1947)).

Starch solutions and insufficiently boiled solutions of tragacanth have poor ability to withstand continuous deformation. The elasticity of starch solutions decreases sharply on addition to oleic acid. Insufficiently boiled tragacanth solutions are very elastic; on longer boiling they become plastic. Na alginate is a good thickener. The practical use of intensively boiled tragacanth is justified by the need of nonelastic products.

Text. Research J. July 1947

Rheological Properties of Viscose

Studies on the structure of viscose with special reference to filtering properties. Tryggve Bergek and Thor Ouchterlony. *Svensk Papperstidn.* **49**, 470–83 (Oct. 1946). (In English.)

Viscometric evidence is presented for the existence of structure in viscose solutions. At very low pressures viscose flows in the manner of a Newtonian liquid. If the pressure is increased above a certain value the viscosity begins to fall rapidly. At a certain value of the driving force, however, the fall in viscosity becomes less sharp. On further increase in the stress a point is finally reached where the viscosity again begins to fall rapidly. Thus the flow curve exhibits two "points of structural turbulence." It is concluded that the pressure effect on the viscosity is due partly to the nonspherical nature of the primary particles, and partly to the fact that the aggregated secondary particles are held together by forces smaller than the maximum flow stresses occurring in the described experiments, and certainly smaller than the stresses prevailing in the capillaries of spinnerets. Thus cellulose xanthate in a technical viscose occurs partly in the form of primary particles (molecules or micelles) and partly as secondary particles formed by the aggregation of primary particles. Relatively weak forces hold the aggregates together and they can be deformed or torn apart by the forces arising when viscose flows. That this particle

aggregation is reversible is shown by mechanically working the viscose, as by filtering or passing through an emulsifier. The viscosity falls off rapidly but is gradually restored to the original value on standing for several hours. On the basis of this picture, and other experiments that are described, Mark's interpretation of the minimum in the viscosity curve of viscose during ageing is confirmed. It is further shown that clogging of viscose filters is due more often to xanthate aggregates than to impurities. A. R. Martin

Text. Research J. July 1947

Urea-Formaldehyde Reaction

A kinetic study of the urea-formaldehyde reaction. Lloyd E. Smythe. *J. Phys. & Colloid Chem.* **51**, 369–78 (Mar. 1947).

The reaction between urea and formaldehyde in aqueous solution within defined conditions has been shown to be mainly of the slow bimolecular variety. Determined values for *E*, *Z*, and *P* are given and discussed in the light of present knowledge of bimolecular reactions in solution. A method for estimating the free formaldehyde during the course of a urea-formaldehyde reaction is presented. Author

Text. Research J. July 1947

BLEACHING: DYEING: FINISHING

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Residual Silica in Peroxide Bleaching

Determination of residual silica on cotton in peroxide bleaching. B. Dubose and V. B. Holland. *Am. Dyestuff Reptr.* **36**, 227–8 (May 5, 1947).

A method for the determination of silica in fibers, yarns, or fabrics of cotton, is submitted, which is based on ashing, removal of interfering substances with perchloric acid, fusing, and the development of the silicomolybdate complex for color measurement. Typical analyses of residual silica in cotton sheeting are shown from the course of a continuous peroxide bleaching process. Tetrasodium pyrophosphate in the silicate bath tended to reduce residual silica to a minimum, whereas caustic soda and soda ash caused a very pronounced increase in residual silica in the goods. Authors

Text. Research J. July 1947

Everglaze

The Everglaze process. Arnold L. Lippert. *Textile Industries* **111**, 57–8, 139 (Mar. 1947).

Description of a process said to result in a durable, lustrous finish on fabrics by simultaneously glazing or calendering and polymerizing a thermosetting resin of the urea-formaldehyde or melamine-formaldehyde types. The glazed fabric is said to withstand repeated laundering and dry-cleaning with only slight deterioration of finish. The process is covered by patents.

H. J. Burnham

Text. Research J. July 1947

Flameproofing

Flameproofing of cotton fillers in plastic laminates. Simon Williams, John B. Alfers, and Carl M. Furgason. *Modern Plastics* **24**, 151–3, 190 (1947); cf. *C.A.* **39**, 1082[3] (through *Chem. Abstr.* **41**, 2933*d* (May 10, 1947)).

Ignition time, burning time, afterglow, water absorption, dielectric, bonding, tensile, impact, and flexural strengths, and the power factor were determined on cotton-based laminates, prepared from cotton fabric or web impregnated with a *cresol-CH_2O* resin (Bakelite BV1112), a *melamine-CH_2O* resin (Melmac 402) or Laminac. The fabric or web base was flameproofed with the following salts: urea, $(NH_4)_2HPO_4$ (2:1); borax, H_3BO_3(7:3); $NH_4H_2PO_4$; borax, H_3BO_3, $NH_4H_2PO_4$ (7:3:5); Zn borate. The salts improved flame- and glowproofness in all cases, but melamine laminates were flameproof even without impregnation. However, they lowered the mechanical properties, and also the electrical properties when wet (not when dry). The use of impregnated cotton fillers is discouraged, but for low-cost purposes, a combination of borax-H_3BO_3-impregnated cotton treated with Bakelite BV1112 is fairly satisfactory.

Text. Research J. July 1947

Moiré Finishing

Moiré finishing of today's fabrics. H. A. Holterhoff. *Am. Dyestuff Reptr.* **36**, P150–2 (Mar. 24, 1947).

The basic principles of the moiré process, the several methods or styles produced, fabrics suited to the treatment, fastness properties of the finished moiréd article, and the problems which arise in the moiré trade are discussed. Essentially, the moiré process produces luster, and lines or shadows forming a definite pattern; the first effect is brought about by subjecting two identical fabrics, face to face, yarn for yarn, to heat and pressure, while the lines are produced in the same way except that the respective positions of the two fabrics are varied in a regular manner with respect to their woven structure. Fabrics suitable for moiréing are, in the order of popularity, taffetas, bengalines, poplins, faille crepes, jacquard failles, tinsel failles. The moiré effect on acetate is fast to pressing, dry cleaning, and cold water, and on nylon it is also fast to laundering. Moiré finishing, by virtue of its ability to cover up weaving, dyeing, and finishing defects, is sometimes used to convert mill seconds into firsts.

K. S. Campbell

Text. Research J. July 1947

Rotproofing

The effect of weathering on various rotproofing treatments applied to cotton tentage duck. C. H. Bayley and Muriel W. Weatherburn.

Can. J. Research **25F**, 92–109 (1947); cf. *C.A.* **40**, 4527[9], 4890[8] (through *Chem. Abstr.* **41**, 2905*f* (May 10, 1947)).

Cotton tentage duck treated with Fe_2O_3-CrO_3 ("mineral khaki"), $CuCO_3$-Fe_2O_3 ("Cu-Fe"), cuprammonium, cutch-cuprammonium, Cu 8-quinolinate, Cu glyoxime, 2,2′-dihydroxy-5,5′-dichlorodiphenylmethane, Zn dimethyldithiocarbamate, Cu naphthenate, Cu hydroxynaphthenate, Zn naphthenate, and Hg naphthenate, showed varying degrees of breaking-strength loss when subjected to outdoor weathering during the summer months. The losses were in no case greater than that of the untreated fabric, and certain treatments, such as mineral khaki and cutch-cuprammonium, gave considerable protection against loss in breaking strength. With Cu naphthenate, Cu hydroxynaphthenate, and Hg naphthenate the degree of chemical degradation as measured by cuprammonium fluidity was somewhat greater than that of the untreated fabric. The presence of a waterproofing treatment consisting of a mixture of petroleum-base waxes in addition to the rotproofing treatments usually resulted in increased breaking-strength loss. The water-resistance of the waxed samples showed a slight-to-pronounced increase on weathering. In general there was considerable loss of rotproofer as a result of weathering; with the Cu compounds this loss was of the order of 37% to 90%, but was reduced to 6% to 44% by the presence of wax. Weathering produced an almost complete loss of the two Zn compounds, 2,2′-dihydroxy-5,5′-dichlorodiphenylmethane and Hg naphthenate. Losses of metal from Cr-Fe proofings were negligible even in the absence of wax proofing. The degree of rot-resistance as judged by soil burial was greatest in the fabrics treated with Cu, and was increased by the presence of wax. The water-resistance of samples subjected to soil burial was frequently decreased before the occurrence of any marked loss in breaking strength; this indicates microbiological attack on the wax coating prior to attack on the cotton fabric.

Text. Research J. July 1947

Detection of Azo Dyes

Color reaction of certain classes of azo dyes with copper. W. A. Alexander. *Analyst* **72**, 56–60 (1947) (through *Chem. Abstr.* **41**, 3018*e* (May 20, 1947)).

A chance observation of the behavior of Bordeaux B with dilute Cu^{++} solutions led to the discovery that a certain class of dyes can be distinguished by the reaction, and under certain conditions it can be used as a sensitive test for Cu^{++}. Apparently the dyes tend to adsorb $Cu(OH)_2$. To a few drops of a 0.05% aqueous solution of the dye add 10 ml. of 0.0001–0.001 *M* Cu^{++} solution and then sufficient NaOAc to bring the pH to about 8.5. Carry out a control test without any Cu. Most of the dyes that react are pink or red, and after the reaction the color is yellow to brown, but in 2 cases the change is from blue-violet to blue-gray. As little as 1γ of Cu can be detected in 10 ml. of solution by the reverse test with a reactive dye. Dyes sensitive to Cu contain an azo group linked in the 2 or 1 position to sulfonated 1- or 2-naphthol. Those derivatives of 1-naphthol are substituted in the 4 or 5 position with HSO_3^- groups, while those from 2-naphthol are substituted in the 3 or 6 positions. In both classes, the 8 position may be occupied by HSO_3^- or OH.

Text. Research J. July 1947

Direct Dyes

Dyeing properties of direct cotton dyes. F. L. Goodall. *Can. Text. J.* **64**, 43–4 (Jan. 24, 1947).

Direct cotton dyes are classified with respect to their rate of exhaustion and rate of migration under constant dyeing conditions. Factors said to control the rate of exhaustion are discussed.

J. A. Woodruff

Text. Research J. July 1947

Diffusion of Dyes

Colloid-chemical studies on dye solutions. I. Diffusion velocity of some benzidine dyes. Noboru Ando. *J. Chem. Soc. Japan* **64**, 1192–6 (1943) (through *Chem. Abstr.* **41**, 3299*c* (May 20, 1947)).

The diffusion constants of Benzopurpurin 4B, Chicago Blue 6B, and Diamine Sky Blue A were determined at 25° in aqueous solutions of NaCl of various concentrations. From the results the aggregation of the micelles of these dyes in NaCl solution is discussed. **II. Electric conductivity of the dyes obtained from cresidine and metanilic acid or sulfanilic acid.** *Ibid.* 1305–10. The electric conductivity of cresidine metanilate, dicresidine metanilate, cresidine sulfanilate, and dicresidine sulfanilate prepared from cresidine, metanilic acid, and sulfanilic acid was determined at 25°, 40°, and 60° in varying concentration. From the results, the aggregation of dye molecules is discussed in the light of the electrolyte theory. **III. Electric conductivity of benzidine diazo dyes.** *Ibid.* 1431–40. Electric conductivities of Congo red, Benzopurpurin 4B, Azoleserin, Benzoazulin G, Nippon Direct Blue, Diamine Blue 3B, Diamine Sky Blue A, and Chicago Blue 6B have been determined and the results are summarized. The influence of substitution group upon the conductivity is discussed.

Text. Research J. July 1947

Dyeing Acetate Locknit Fabric

The dyeing of Celanese locknit fabric. L. C. Mitchell. *J. Soc. Dyers and Colourists* **63**, 102–5 (Apr. 1947).

Practical suggestions for handling the greige knitted acetate fabric are given, its preparation for dyeing discussed, and methods of scouring, dyeing, stripping, and finishing are reviewed.

K. S. Campbell

Text. Research J. July 1947

Effect of Ash on Cotton Dyeing

How the mineral content of cotton can affect beam dyeing with vat colors. Southeastern Section, AATCC. *Am. Dyestuff Reptr.* **36**, P104–7 (Mar. 10, 1947).

Uneven dyeing when vat colors are used on beams was traced in this case to the form in which the calcium and magnesium portion of the natural cotton ash was present in the cotton fiber. Calcium and magnesium ash was found to be readily removable in an alkaline dyebath but was subsequently redeposited (when the caustic soda was added) on the outside winding of the beams as an insoluble hydroxide which could not be removed by soaping. This deposit prevented uniform flow of dye liquor through the beam and poor dyeing resulted. A preliminary boil-out in acetic acid removed the troublesome ash and level results were obtained. Apparently the difficulty encountered in this instance was peculiar to a particular variety of cotton since another type yielding a practically identical ash analysis did not perform in this manner.

K. S. Campbell

Text. Research J. July 1947

Direct Dyeing

Dyeing of cotton with direct dyes: Effect of temperature, dye concentration, and anionic surface-active agents. R. P. Graham and W. J. Seagers. *Can. J. Research* **24F**, 474–93 (1946) (through *Chem. Abstr.* **41**, 2903*d* (May 10, 1947)).

The rate of dyeing and equilibrium sorption of a direct dye-natural cotton system, in the presence of 4 g./l. of NaCl, was studied as affected by temperature, dye concentration, and anionic surface-active-agent concentration. Five-g. skeins of $\frac{1}{4}$'s count cotton were dyed with purified Calcodur Blue 4GL (*Colour Index 533*) in a 250 ml. dye bath with constant agitation. Dye-pots were equipped with a reflux condenser and provisions for dye-liquor sampling. Dye concentration in the liquor was measured spectrophotometrically on periodically drawn samples. Increase of initial dye concentration resulted in an increase of time required to reach equilibrium, in the final dye concentration in the bath at equilibrium conditions, and in the rate of sorption. Increase of temperature resulted in an increase in rate of sorption, and in a decrease of equilibrium sorption and of time to equilibrium. Anionic surface-active agents of the sulfated aliphatic ester and sulfonate types accelerate the rate of sorption in the presence of NaCl. This is true both of commercial and of purified products. It is claimed that these agents exert their effect by promoting wetting and swelling of the fibers, and not by any action on the dye. No effect of anionic-active agents on dye-solution absorption spectra was noticed.

Text. Research J. July 1947

The Dyeometer

The Dyeometer: An instrument for studying color reactions. R. H. Kienle, G. L. Royer, and H. R. McCleary. TEXTILE RESEARCH JOURNAL **16**, 616–26 (Dec. 1946).

Photographs, sketches, and written description are given of the Dyeometer, which is an instrument permitting continuous photometric measurement of the liquor contained in its dye bath. The construction is said to permit rigid control of the temperature and volume of the dye bath, the circulation of the liquor, the motion of the material being dyed, and the condition of the surrounding atmosphere. Essentially the apparatus consists of a glass dyebath chamber of 400-cc. volume connected to an interchangeable transmission cell unit, specially designed stirrers which hold and rotate the material to be dyed, a gas lift for circulation of the bath, and a thermoregulator connected to a Fisher-Serfass electronic relay for controlling a set of heating coils. A detailed description is given of the method of temperature control of the dye bath. When in use the cell unit is placed within the aperture of the photometric apparatus. Examples are given of some of the uses of the instrument such as determining the percentage of dye-bath exhaustion per unit time under varying dyeing conditions, the study of the rates of reduction of vat dyes, and the determination of the rates of chromation of dyes in solution. Spectrophotometric transmission curves of the dye liquor can be drawn at intervals using an automatic recording spectrophotometer, or, in the case of rapid measurement, the change in transmittance at the wave length of maximum absorption can be used. J. A. Woodruff

Text. Research J. July 1947

Kupensaure Process

An evaluation of the Kupensaure process. Piedmont Section, AATCC. *Am. Dyestuff Reptr.* **36**, P142–8 (Mar. 24, 1947).

The Kupensaure process, a new development in the application of vat colors, which originated in Germany, in which a reduced vat-dye solution is neutralized with acetic or formic acid before its application to the goods to be dyed, was tested for suitability for about 60 vat colors at high and low concentrations. Tables showing results, and practical formulas are presented. The free vat acid formed by neutralization of the alkali in the bath is in an extremely fine state of dispersion or in colloidal solution, is relatively stable to oxidation, and has practically no affinity for the fiber. It is, therefore, in a state comparable to a pigment dispersion with respect to uniform application to fabric and has some advantages over the latter. Although by no means universally advantageous or applicable, the vat-acid process may be very useful in obtaining level results with certain vat dyes, particularly in light shades and with hard, tightly wound beams or packages. Better color value may be obtained because less

retarding agent is necessary to effect penetration. K. S. Campbell

Text. Research J. July 1947

Metachrome Dyeing

Metachrome dyeing. Part II. Minimizing the adverse effect of iron on fastness of chrome colors through use of the metachrome method of dyeing. C. H. Schmitt. *Am. Dyestuff Reptr.* **36**, P238–44 (May 5, 1947).

Experiments are described which show that dyeing wool by means of the metachrome process when an excess of iron is present gives superior results not only in shade but in fastness to light, carbonizing, fulling, and decatizing. Less than one part per million of iron in the dye bath can often cause serious trouble. All but a few chrome dyes, and especially in top-chrome dyeing, are affected by iron; this is due to the ease with which these dyes form iron lakes. K. S. Campbell

Text. Research J. July 1947

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Banana-Stem Fiber

Fiber from banana-plant stem. Bibhutybhusan Biswas and Dattatraya Y. Athawale. *J. & Proc. Inst. Chem.* (India) **18**, 96–101 (1946) (through *Chem. Abstr.* **41**, 2904*c* (May 10, 1947)).

Chemical analysis shows that banana fiber closely resembles Manila hemp in cellulose content (64.47% and 64.72%). A 70% yield of a fiber resembling flax can be obtained from banana fiber by a series of steps including digestions in 1% K_2CO_3 or Na_2CO_3 and hypochlorite (0.3% Cl_2). References.

Text. Research J. July 1947

New Synthetic Fiber

Synthetic fibers. VI. ε-Caprolactam polymer. Kohei Hoshino, Kisaburo Noissiki, and Koki Aikawa. *J. Chem. Soc. Japan* **62**, 1202–7 (1941); cf. *C.A.* **37**, 4698[6] (through *Chem. Abstr.* **41**, 2904*a* (May 10, 1947)).

ε-Caprolactam was polymerized to linear polyamide in the presence of H gas at 250–300°. An x-ray diagram was made of the fiber obtained by spinning of this polymer. Hydrolysis product of the polymer by H_2SO_4 gave α-amino-caproic acid. **VII. Synthesis of nylon intermediates. I.** Kohei Hoshino and Kisaburo Noissiki. *Ibid.* 15–8. Adipic acid was synthesized by oxidizing cyclohexanol with HNO_3, the yield being about 76%. NH_4VO_3 has hardly any catalytic effect. With NH_3 and adipic acid at 380° in the presence of silica gel, the yield of adiponitrile reaches about 18%. A 95% yield of hexamethylenediamine from the nitrile was obtained. Preparation of a Co catalyst is described.

Text. Research J. July 1947

Synthetic fibers. VIII. Synthesis of polycaproamide intermediates. 1. Kohei Hoshino, Kisaburo Noissiki, and Koki Aikawa. *J. Chem. Soc. Japan* **63**, 1170–4 (1942); cf. *C.A.* **41**, 2904*b* (through Chem. Abstr. **41**, 3300*d* (May 20, 1947)).

Cyclohexanone oxime was prepared by the action of hydroxylaminedisulfonate and by the action of the electrolytic reduction product of HNO_3. The influence of the various factors (amount of H_2SO_4, concentration of H_2SO_4, neutralizing agent, extraction agent, purity of oxime) on the synthesis of ε-caprolactam from cyclohexanone oxime was studied. No simple conclusions are drawn. **IX. Caprolactam polymer. 2.** Kohei Hoshino and Kisaburo Noissiki. *Ibid.* 1175–8. The literature on the polymerization of ε-caprolactam is reviewed. The conditions for polymerization were studied. Suitable conditions are: temperature 245°, time over 30 hrs., amount of water added to 1 molecule ε-caprolactam 0.1 molecule. The mechanism of polymerization is discussed and the following formulas of viscosity are proposed. $n = A + BP_w$, $\eta = CP_w + DP_w^2$, where P is degree of polymerization, and A, B, C, and D are constants. **X. Copolymer. 1.** Kohei Hoshino and Koki Aikawa. *Ibid.* 1182–8. A copolymer of ε-caprolactam and the adipic acid salt of hexamethylenediamine was synthesized. No simple definite relation was found between the properties of the copolymers and the strength of the fibers spun from them.

Text. Research J. July 1947

Elastic Properties of Fibers

The elastic properties of textile fibers. I. Pierre Chevenard and Georges Champetier. *Bull. soc. chim.* **1946**, 464–74 (through *Chem. Abstr.* **41**, 2247*g* (Apr. 10, 1947)).

A micro-apparatus (cf. *C.A.* **40**, 5254[9]) is used to differentiate ramie, raw silk, wool, and nylon. Silk and nylon are compared to corrugated steel wire in which the elasticity is a reversible function. Straightening and permanent deformation result from slippage of adjacent chains. Ramie fibers are compared to steel wires having double corrugation. The change from α to β keratin results from an unfolding of polypeptide chains.

Text. Research J. July 1947

Evaluation of Fabrics

Test for the examination and evaluation of fine fabrics. Introduction of a standard fabric. Gustav Dreifuss. *Textil-Rundschau* **1**, 170–4 (Dec. 1946).

Since it has been found that the properties of woven fabrics cannot always be derived correctly from the measurements of the fibers and yarns of which they are made, and since special effects, such as resistance to shrinkage and crushing, water-repellence, etc., can be deter-

mined only on the finished fabric, the testing of the wearing quality of the latter has gained considerably in importance. A survey is given of the present status of this art of testing. A distinction is made between (1) the general qualitative test—i.e., determination of tensile strength, breaking length, construction, etc.,—to find out whether the fabric has the expected structure and has not been damaged in the spinning and weaving processes; and (2) the wearing quality test. In the case of (2) it is known that the fabric is intended for a special purpose and the test methods are chosen accordingly. Both tests naturally have points of contact and overlap in part. (2) is divided into well-established and well-supervised wearing tests on human beings, and laboratory measurements, including exposure to high temperatures, stress, pressure, crushing, water, washing, crocking, friction, and light. The results of both are compared and relationships established. A new suggestion is the use of a "type," i.e., a standard fabric, well-known in industry, which has become a standard material through many years of wear. The specific example given is a cotton shirt poplin.

Text. Research J. July 1947 Ilse Zeise

Thermal Properties of Fabrics

Physical properties of fibres and textile performance. A. B. D. Cassie. *J. Text. Inst.* **37,** P154–67 (July 1946).

It is shown that fine-diameter fibers are essential not only for the flexibility of clothing, but also to provide a large total fiber surface. The large fiber surface is essential to provide a drag on air movement, and it is this drag which is commonly termed "the power of fabrics to entrap air." It is, in fact, the drag on air movement due to the large fiber surface that gives fabrics their good heat insulation. The large fiber surface is also necessary to bring the material of the fibers into intimate contact with the water vapor of the atmosphere. It is shown that when this intimate contact is available, the heat associated with changes of regain provides much protection against chill due to sudden changes of temperature. The fine diameter of fibers ensures a large total surface, but this surface may not be accessible to air because of close packing of the fibers in the yarns. Bulk density and air-permeability measurements show that the fiber surfaces in ordinary wool fabrics are wholly accessible to air, but the accessibility of other fiber surfaces is doubtful. Finally, the properties of fibers required to make their surfaces in the yarns accessible to air are discussed, and it is shown that a large torsional rigidity, rather than a large Young's modulus, gives to fabrics the light, open, and uniform structure which is necessary to make full use of the outstanding merits of the large fiber surfaces. Author

Text. Research J. July 1947

Jute Yarn Properties

Indian research on physical properties of jute yarns. Anon. *Fibres, Fabrics, and Cordage* **14,** 60 (Feb. 1947).

This article reviews briefly 4 recent publications of the Indian Central Jute Committee, as follows: Assessment of Spinning Quality, by C. R. Nodder (8 pp., price 6d.): Some Notes on the Strength of Jute Ply Yarns, by C. R. Nodder (8 pp., price 6d.); The Single Thread Strength of Jute Yarns in Relation to Test Length, by K. R. Sen and C. R. Nodder (19 pp., price 1s.6d.); The Effect of Moisture on the Strength of Jute Yarns, by K. R. Sen, S. B. Bandyopadhyay, and C. R. Nodder (10 pp., price 6d.). Among factors considered in estimating spinning quality of jute from spinning tests are the amount which must be cut off from the root end for yarn of desired finenesses, color, prevalence of "faults," as well as strength, fineness, and flexibility of yarn. Maximum strength in a 3-ply jute yarn was obtained with about 3.1 t.p.i. doubling twist. Within wide limits relative humidity does not greatly affect yarn strength but direct wetting is detrimental, particularly to fine-grade yarns.

R. B. Evans

Text. Research J. July 1947

Mercerization

Mercerization of cotton fabrics. III. Qualitative analysis. Florencia Hernández de Rembado and Alfredo A. Rembado. *Industria y quím.* (Argentina) **8,** 209–14 (1946); cf. *C.A.* **41,** 1845*f* (through *Chem. Abstr.* **41,** 3301*b* (May 20, 1947)).

Microscopic observation of fibers, especially after treatment with dyes, serves to identify mercerized cotton. **IV. Quantitative analysis.** *Ibid.* 214–17. Methods are described for analyzing fabrics for moisture and for nonfibrous material and for determining the amounts of wool, viscous rayon, acetate rayon, and natural silk mixed with cotton. A procedure for determining the efficiency of humectants to be used in the mercerization bath is described. **V.** *Ibid.* 245–9. The dimensions, twist, elasticity, and torsion-resistance of mercerized fabrics were measured as a function of the temperature and time of mercerization and concentration of NaOH, Na_2CO_3, and Mercerol B.P. (a mixture of PhOH, mixed cresols, and a small amount of high-molecular-weight alkyl sulfate, used as a humectant) in the mercerizing bath. Dimensions, twist, and elasticity were approximately constant for all conditions, but torsion-resistance reached a maximum for baths containing NaOH corresponding to 15–35° Bé. and 1.5% Mercerol B.P., and for a mercerizing temperature of 90°. Varying the tension during mercerization affected the properties of loosely woven fabrics only. The best measurements for controlling the process of mercerization are dye absorption and absorption of Ba$(OH)_2$, described in a preceding paper of this series.

Text. Research J. July 1947

Resins from Fiber Tows

Plastics from fiber tows. Bibhutybhusan Biswas and Dattatraya Y. Athawale. *J. & Proc. Inst. Chem.* (India) **18**, 92–6 (1946) (through *Chem. Abstr.* **41**, 2932*h* (May 10, 1947)).

Satisfactory plastic molding powders were made from the tows of hemp, flax, and jute by heating the fibers with an equal weight of phenol or cresol, then washing, drying, and powdering. 11 references.

Text. Research J. July 1947

Serviceability of Wool Serge

Relative serviceability of three weights of wool serge. Lillian O. Lund, Ethel L. Phelps, Helen Ward Norton, and Barbara Bailey Miller. J. Home Econ. **39**, 81–4 (Feb. 1947).

All-wool serge in 12-, 14- and 16-oz. weights was made into men's trousers which were worn daily by men students until withdrawn after 1,500, 3,000, and 4,500 hrs. of wear. All three serges lost in weight and thickness but after 4,500 hrs. the 16-oz. fabric was still equal in thickness to the new 12-oz. fabric. Losses in breaking strength, bursting strength, and elongation are also given. Ageing or storing of control fabrics was found to have little effect on their characteristics.

Text. Research J. July 1947 R. B. Evans

Noble Comb

An improved method of dabbing on the Noble comb. T. F. Griffin. *J. Text. Inst.* **38**, P91–5 (Mar. 1947).

The object of this invention is to eliminate the excessive wear that takes place at the "heel" of the dabbing brush used on a Noble comb. Numerous attempts have been made in the past to overcome this fault but all previous efforts have been made on combs constructed on the original Noble comb principle, in which the large and small circles are in the same plane. In the new method of dabbing the circles are arranged in such a manner that the wool can be dabbed into the circles in a way which reduces the wear on the brush to a minimum. Author

Text. Research J. July 1947

Warper Drive

Electronic warper drive gives constant yarn speed. R. J. Demartini. *Textile World* **97**, 121, 172–3 (Apr. 1947).

A system of driving spindle-driven warpers in which motor speed must be decreased as the diameter of the beam increases in order to maintain constant yarn speed. A signal from a tachometer generator driven by the delivery roll on the compress roll is used to control the output of an electronic rectifier for supplying the main D.C. driving motor. This is said to result in a constant yarn speed within 1% from empty to full beam. H. J. Burnham

Text. Research J. July 1947

O.T.S. REPORTS *

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Cellulose Degradation

Degradation of cellulose. Philadelphia Textile Institute. PB A 63557, Jan. 1945; 48 pp.; microfilm, $1.00—photostat, $4.00 (through *Bib. and Sci. Ind. Reports* **5**, 511 (May 9, 1947)).

This report covers an investigation for the purpose of finding a sewing thread more durable than the cotton thread now used for sewing the ends of bags containing phosphate fertilizer sent abroad under the Lend-Lease program. It was also necessary to devise an accelerated test for reproducing the conditions occurring in the sewed tests. A number of threads and impregnated threads were subjected to the accelerated test (burial in fertilizer and acid dipping) and the results noted. Mohair was recommended as the best available fiber for replacing the cotton thread. Two other fibers were found to be superior to cotton: du Pont Fiber "A," however, was not available and would be much more expensive than cotton when available; and triethanolamine-impregnated cotton was too sticky to be used as a sewing thread. Photographs, tables, and graphs are included. The report covers work performed under a War Production Board contract.

Text. Research J. July 1947

* Copies of these reports may be obtained directly from the Office of Technical Services, Department of Commerce, Washington 25, D. C. Orders should be accompanied by check or money order payable to the Treasurer of the United States.

German Carpet Industry

German carpet industry. P. W. Robinson. (BIOS Final Rept. 872, Item 22, 31.) PB A 63697, Dec. 1946; 57 pp.; microfilm, $2.00—photostat, $4.00 (through *Bib. Sci. and Ind. Reports* **5**, 405 (May 2, 1947)).

The German carpet trade was closed down for a greater or lesser period during the war, and in some cases production which had started has dwindled or stopped altogether for lack of materials. The major part of all present production is with substitute materials, and there seems as yet to be no properly organized system of supply. This report consists of accounts of visits to German and Austrian carpet factories and carpet machine factories; details of processes and machines used in dyeing, winding, warping, weaving, and finishing; and raw materials generally in use. Appendices 1 and 2, literature and samples, may be consulted at: The B.O.T. German Division, Documents Unit, Lansdowne House, Berkeley Square, W.1, London. Appendix 3 presents an index. Photographs and sketches are included. A supplementary report on textilose yarn, compiled from particulars supplied by F. Moss of Textilose Ltd., is also included. Plants reported on individually are:

Montforts Maschinenfabrik, Munich-Gladbach (finishing machinery for flax and hemp; sizing machines); Wm. Schlafhorst Maschinenfabrik, Munich-Gladbach (winding and warping machines; warp tensioners); Jan Gusken, Dülken (double-cloth looms; high-speed beamer; Jacquard split-cloth looms); Felix Tonner, Dülken (double-cloth looms; beaming machines); Carl Zang, Krefeld (Jacquard and preparing machinery; cloth looms); Gebr. Schoeller, Düren (tapestry, Wilton plains, bouclé, printing, dyeing; sackcloth with art silk and hemp and paper yarn; blankets and tarpaulins); Vorwerk, Wuppertal-Barmen (furnishings; Wilton carpets; gripper ax.; blankets; sacking); Mertens & Frowein, Neviges (Wilton looms; double-cloth looms; moquette looms; Jacquards; stamping machines); Carl Schlemper, Solingen-Ohligs (carpet wires; carpet blades; face-to-face cutters; chenille cutters); Otto Geller, Leichlingen (bouclé; tablecloths; coarse woolen cloth; plain Wilton; paper sacking); Herforder Teppich Fabrik, Herford (bouclé); Verwaltung Bessert, Nettelbach & Mertens, Hamlyn (bouclé; Wilton; gripper ax.); Otto Kuhlmann, Hamlyn (bouclé; paper ingrain); Wehra A.G. Teppich & Möbelstoffweberei, Wehra-Baden (Wilton; face-to-face Wilton, called tournai; bouclé; furnishings; coconut matting; paper sacks; hemp matting; paper matting); and Alfred Rogler Sohn, Gefrees (furnishing fabrics and industrial plush).

Text. Research J. July 1947

German Felt Manufacture

Manufacture of wool felt, fur felt, and velour hoods, hats and capelines in Germany. Geoffrey C. Bourne and others. (BIOS Final Rept. 879, Item 22.) PB L 67454, n.d.; 21 pp.; microfilm, $1.00—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* **5**, 511 (May 9, 1947)).

The purpose of the investigation was to examine the German methods of production and the machinery employed in the manufacture of wool felt, fur felt, velour hoods, hats and capelines. The impression formed by the investigating team was that, apart from the factories in the Russian Zone, which were not visited, the available production in Germany is very small, not sufficient to supply the needs of its own home market and certainly insufficient for any export trade. In general, the methods of production showed little, if any, advance over the methods employed in Great Britain. The vast majority of the machines installed in the factories visited were of conventional design, similar in construction to those used in many British hat factories. The German trade is working under great difficulties with respect to raw materials; in wool they have a few noils and use mostly Bavarian wools of low quality, and in fur they have had to depend entirely on tame fur and a very little hare's fur; chemical substitutes are in general use. Brief accounts of the work of the following plants are presented in appendix A: K & R Lembert, Augsburg; Rockel & Co., Alsfeld; R & M Wegener, Blitzenrod; Resolut Hutfabrik G.m.b.H., Koppern and Friedrichsdorf; and Mayser Hutfabrik G.m.b.H., Ulm (Donau). Machinery is described in appendix B, and lists of factories visited and German trade terms are given in appendices C and D. Sketches A–J are drawings of machinery and parts.

Text. Research J. July 1947

Denkendorf Reports

Research reports (Berichte). Zellwolle Lehrspinnerei G.m.b.H., Denkendorf, Germany. (QM Textile Series Rept. 14.) PB A 75802, Nov. 1946; 186 pp.; microfilm, $4.00—photostat, $13.00 (through *Bib. Sci. and Ind. Reports* **5**, 511 (May 9, 1947)).

This collection of reports was translated and prepared under the direction of the Research and Development Branch, Office of The Quartermaster General. These reports were published through 1944, by a highly significant research organization, established by the German staple fiber industry and the German Government in 1938 at Denkendorf. A completely equipped mill of about 7,000 spindles was devoted wholly to research on the spinning of a single type of textile fiber. Many of the reports deal with aspects of staple fiber processing on which research has apparently not been conducted in this country. The following subjects are covered in the reports: (1) processing staple fibers in long-staple (worsted) spinning; (2) the Denkendorf process for spinning plain wool-type staple fibers; (3) comparison between double gill boxes, porcupine drawing frames, and hackle drawing frames in worsted spinning; (4) processing staple fibers on the 3- and 4-roll cotton spinning mill; (5) factors influencing yarn characteristics; and many others. Part of the collection is devoted to reports on scientific and technical investigations. Every practicable step has been taken to keep the organization together at Denkendorf. Its program has been carefully reviewed by research investigators of the Office of The Quartermaster General, and certain projects believed to be of particular value to the American textile industry have been given a high priority in its research program. One of the projects has to do with the causes of neps in the spinning of rayon staple yarns. Others are concerned with further research in the draft field. It is planned to make available to American industry the future research reports of this organization. Data tables, diagrams, drawings, graphs, and photographs are included.

Text. Research J. July 1947

MISCELLANEOUS

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European Carpets

The history and tradition of European carpets. C. S. Newton. *J. Text. Inst.* **38**, P107–118 (Mar. 1947).

A lecture with 16 illustrations of carpet patterns.

Text. Research J. July 1947

Cotton-Gin Census

Cotton-ginning machinery and equipment in the United States—1945. Bureau of the Census, U. S. Department of Commerce. Washington, U. S. Govt. Printing Office, 1946. 86 pages. Price, 35 cents.

This publication presents results of a census of cotton gins, giving ownership, bales ginned, type of power used, type of gins, etc., by counties, states, and for the nation.

Text. Research J. July 1947 R. B. Evans

Shortcomings of Dye Industry

Shortcomings of the dyeing industry as seen by the launderer, drycleaner, and garment dyer. S. C. Turner. *J. Soc. Dyers and Colourists* **63**, 105–6 (Apr. 1947).

The need for pooling knowledge among the original producers and the trades which subsequently handle the products, for the benefit of their mutual customers, is emphasized. K. S. Campbell

Text. Research J. July 1947

Dyeing and Finishing Worsteds

Dyeing and finishing worsted and serge suitings. W. Stansfield. *Can. Text. J.* **63**, 43–4, 54 (Feb. 21, 1947).

A review of practical information.

Text. Research J. July 1947

Textile Finishes

Finishes for textiles. Rick Mansell. *Am. Paint J.* **31**, 70, 72, 74, 76 (1947) (through *Chem. Abstr.* **41**, 2905*a* (May 10, 1947)).

Creaseproof, water-repellent, fireproof, and fungicidal treatments are considered.

Text. Research J. July 1947

Fiberglas Economics

Fiberglas. Anon. *Fortune* **35**, 87–91, 225–9 (Jan. 1947).

History of glass fiber and operations of Owens-Corning Fiberglas Corp. are described. The company's sales increased from $3,500,000 in 1939 to $56,000,000 in 1944 with expansion to $100,000,000 expected by 1950. At present it has a total of 6,500 employees of whom 700 are research personnel. The company recently offered to license many of its patents. Present and potential uses of Fiberglas are described.

Text. Research J. June 1947 R. B. Evans

Fire-Resistance

Fire-resistance in aircraft textiles. J. R. Redmond. *Am. Dyestuff Reptr.* **36**, P103, P121 (Mar. 10, 1947).

A discussion of the Civil Aeronautics Administration Proposed Safety Regulation with respect to the fire-resistance of textiles used in cabin interiors. Definitions are given and test methods and acceptable fabric types are described. K. S. Campbell

Text. Research J. July 1947

Testing for fire-resistance. J. R. Redmond. *Am. Dyestuff Reptr.* **36**, P140, P148–9 (Mar. 24, 1947).

A report on the progress of the AATCC Committee on Testing Fire-Resistant Materials.

Text. Research J. July 1947

Flammability of Wearing Apparel

Flammability of wearing apparel. H. E. Hager. *Am. Dyestuff Reptr.* **36**, P141, P149 (Mar. 24, 1947).

A discussion of the problem of legislation regarding flammability of textiles, and its present status. K. S. Campbell

Text. Research J. July 1947

Flax Processing Machinery

Modern flax-preparing machinery: Part I, the hackling machine. Anonymous. *Fibres, Fabrics, and Cordage* **14**, 66–7 (Feb. 1947).

Latest machinery for preparing flax is described. No radical changes have been made in design but substantial improvements have been made in ancillary fittings.

Text. Research J. July 1947 R. B. Evans

Economic Outlook for Henequen

The future of henequen fiber. Walter J. Armstrong. *Cord Age* **46**, 18, 20 (Dec. 1946).

World production of henequen and sisal doubled from 1901 to 1938 but Yucatan's share declined from 100% to only 20%. Henequen is weaker than East African sisal; it cannot be used in marine ropes because of its poor wet strength, and in the future probably will be used only in cheaper-grade ropes. Its market in binder twine has been declining because of increasing use of combine harvester, but an increasing market in baler twine may more than offset this loss. Henequen is used extensively at present as an upholstery material but faces stiff competition from cheaper materials and from foam rubber. Quality and output of henequen can be improved by proper use of fertilizer, by plant breeding research, and by studies to control insect damage. Better grading and cleaning methods also are needed. R. B. Evans

Text. Research J. July 1947

Ramie Processing Machinery

Ramie—Cinderella of bast fibres. Anon. *Fibres, Fabrics and Cordage* **14**, 109–13 (Mar. 1947).

Machines made in England for degumming, preparation, and spinning of ramie are discussed.

Text. Research J. July 1947

Melamine Resins

The melamines. Anon. *Brit. Plastics* **18**, 511–13 (Nov. 1946).

A review of the chemistry, properties, and uses of melamine resins and the products resulting from compounding these with fillers.

Text. Research J. July 1947 R. W. Eyler

Mohair Production and Uses

Mohair: Distinguished fiber of unlimited uses. American Wool Council. *Sheep and Goat Raiser* **27**, 12–14 (Dec. 1946).

Production, grading, and uses of mohair are briefly discussed.

Text. Research J. July 1947

Texas Silk

Texas silk. Richard L. Priess. *Southern Power and Ind.* **65**, 58–60 (1947) (through *Chem. Abstr.* **41**, 3301*a* (May 20, 1947)).

Modern methods of silk-worm raising, including the use of the Burbank mulberry tree and the development of a patented cocoon-reeling machine, may establish this culture as a part-time occupation in the poorer sections of the South.

Text. Research J. July 1947

Silicones

Silicones. L. Sanderson. *Brit. Plastics* **18**, 459–64 (Oct. 1946).

A general survey of resin, liquid, and rubber types. Structure of these compounds, their dielectric properties and resistance to chemical action are described. Applications reported are in molding, electrical equipment, hydraulic devices, lubricants, and protective coatings. Silicone rubber is compared with other types.

Text. Research J. July 1947 R. W. Eyler

Starch Research

A decade of starch research. Thomas J. Schoch. *Baker's Digest* **21**, 17–20, 23 (1947) (through *Chem. Abstr.* **41**, 2921*a* (May 10, 1947)).

5 references.

Text. Research J. July 1947

Printing on Vinyl Film

Printing on vinyl film. C. M. Robbins. *Can. Text. J.* **64**, 45–6, 52, 54 (Jan. 24, 1947).

A résumé is given of the present methods of printing vinyl films. The methods of printing by rotogravure, screen and air brush, and transfer are discussed.

J. A. Woodruff

Text. Research J. July 1947

Exhibition of Print Styles

Print styles. *J. Soc. Dyers and Colourists* **63**, 97–101 (Apr. 1947).

An exhibition of print styles was prefaced by a series of introductory addresses in which the application techniques for the several styles of textile printing were concisely reviewed and some of the economic factors associated with each were discussed. The following were included: (1) block printing, (2) printed dress goods, (3) printing of shirtings, (4) screen printing, (5) West African print styles, and (6) organdie. K. S. Campbell

Text. Research J. July 1947

Specific Surface

Measurement of the specific surface of porous and disperse bodies by their resistance to the flow of rarefied gases. B. Deryagin. *Compt. rend. acad. Sci. U.R.S.S.* **53**, 623–6 (1946) (in English) (through *Chem. Abstr.* **41**, 2626*h* (May 10, 1947)).

Mathematical treatment of a Knudsen flow through a porous diaphragm; from the conclusions obtained it is possible to compute the specific surfaces.

Text. Research J. July 1947

Surface-Active Cations

Properties and uses of surface-active cations. Robert R. Ackley. *Soap San. Chem.* **23**, 39–42, 93, 175 (1947) (through *Chem. Abstr.* **41**, 3311*a* (May 20, 1947)).

The review includes physical, chemical, and colloidal properties, reactions with proteins, cytolytic activity, and miscellaneous applications. 43 references.

Text. Research J. July 1947

Terylene

Terylene—a new material. Anon. *Brit. Plastics* **18**, 505 (Nov. 1946).

A short description of a new synthetic fiber, a polyester derived essentially from terephthalic acid and ethylene glycol. Properties reported include high resistance to light and heat, high initial elastic modulus, resistance to micro-organisms, bacteria, and chemical agents, low moisture absorption, good resilience, and a high ratio of wet to dry strength. 4 photographs.

Text. Research J. July 1947 R. W. Eyler

Viscosity

Some recent advances in non-Newtonian viscosity. Henry Eyring and George Halsey. *J. Colloid Sci.* **2**, 17–19 (Feb. 1947).

A review.

Text. Research J. July 1947

Recovery and Processing of Wool Grease

Recovery and processing of wool grease. W. H. Hillier and S. G. Campbell. *Synthetics and By-Products* **8**, 329–34 (1946) (through *Chem. Abstr.* **41**, 2591*e* (Apr. 20, 1947)).

Twenty % of the world's wool production is washed in Bradford. Severe water contamination led to the development of a recovery plant. A flow diagram shows the process used for removing wool grease from 20,000,000 gal. of sewage daily in which precipitation tanks, biological filters, H_2SO_4 treatments, grease removal, and distillation are utilized. **How research solved the problem of utilizing wool grease.** *Ibid.* 375–80. By the middle of 1935 large amounts of grease thus recovered had accumulated. Applications for this prod-

uct were found in the paint industry, quick-drying water paints, rust preventives, Mg-soap vehicles, axle grease, greasing army boots, etc.

Text. Research J. July 1947

Maintenance of Laboratory Equipment

Maintain testing equipment. Horace L. Pratt. *Textile Industries* **111**, 54–6, 139 (Mar. 1947).

The maintenance of some of the more common instruments used for textile testing is discussed.

Text. Research J. July 1947

Economics of Research

The economics of research. R. Presgrove. *Can. Text. J.* **63**, 44–5, 48 (Nov. 1, 1946).

The effects of research are shown in the reduction of time worked, increased wages, and increased productivity per employee. It is felt that research must be used effectively in overcoming the problems of taxation and other factors retarding research which are after-effects of the war. J. A. Woodruff

Text. Research J. July 1947

Textile Chemistry

Chemical developments in textiles in 1946. Milton Harris and Louise L. Cox. *Chem. and Eng. News* **25**, 96–7 (Jan. 13, 1947).

Chemical progress in textiles in 1946 is reviewed with reference to organizations involved, fields of activity, and chemical developments pertaining to fibers and finishes.

Text. Research J. July 1947 R. B. Evans

Swedish and Danish Textile Industries

Textile production and dyeing in Sweden and Denmark. H. Boothroyd. *J. Soc. Dyers and Colourists* **63**, 77–80 (Mar. 1947).

A report on conditions in the Swedish and Danish textile industries during and following the war. Lack of coal for fuel is the most pressing problem today.

Text. Research J. July 1947

Textile Mill Design

New trends develop in southern textile mill design. Anonymous. *Eng. News-Record* **138**, 805–9 (May 15, 1947).

Trend seems to be toward one-story structures in suburban or rural locations. Plants have structural steel frames and typical bays are 1,000 to 1,500 sq. ft. in area. Walls transfer less heat, reducing requirements for air conditioning, heating, blinds, and awnings if windowless, but small windows have been used in some mills for psychological reasons. In almost all cases, inside walls are glazed with structural tile. A northern hard maple floor laid in asphalt on wood joists resting on a tar-concrete base is generally preferred in dry-process rooms, while cement with special surface and glazed tile is used for wet-processing areas. R. B. Evans

Text. Research J. July 1947

Textile Testing in Germany

Textile testing in Germany. Herbert F. Schiefer, Lyman Fourt, and Richard T. Kropf. *ASTM Bull.* **144**, 61–4 (1947) (through *Chem. Abstr.* **41**, 2247*c* (Apr. 10, 1947)).

Text. Research J. July 1947

Glossary of Textile Terms

A glossary of technical terms pertaining to flax, hemp, and jute machinery and accessories. By Lincojute. *Fibres, Fabrics and Cordage* **13**, 465–6, 473 (Nov. 1946).

Definitions of terms pertaining to machinery used for processing bast fibers are given.

Text. Research J. July 1947

PATENT REFERENCES

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Improved Bleaching Process

Process for bleaching cotton. Stuart M. Rogers (to The Solvay Process Co.). U. S. 2,417,570 (Mar. 18, 1947).

The addition of sodium stannate to hypochlorite bleach baths is claimed to result in bleached fabrics of superior brightness and lower fluidity.

Text. Research J. July 1947 A. R. Martin

Application of Cellulose Ethers

Application of cellulose ethers to textiles. Charles F. Goldthwait, Herbert O. Smith, and Larry B. Barnes (to Claude R. Wickard, as Secretary of Agriculture of the United States of America, and his successors in office). U. S. 2,417,-869 (Mar. 25, 1947).

A cellulose hydroxy ethyl ether is dissolved in cuprammonium solution and applied to a fabric as a finish. The treatment is particularly recommended for mosquito netting as it stiffens the yarns and prevents slippage. The copper remaining in the fabric contributes mildew-resistance. A. R. Martin

Text. Research J. July 1947

Lint-Cotton Cleaner

Lint-cotton cleaner. Eugene H. Brooks (to Continental Gin Co.). U. S. 2,418,694 (Apr. 8, 1947).

A battery of cotton gins, cleaners, and condensers designed particularly to handle mechanically picked cotton. A. R. Martin

Text. Research J. July 1947

Improving Dyeing Properties

Improving the dyeing properties of cellulosic textiles by treatment with formaldehyde and a guanidine salt of an alpha-beta unsaturated carboxylic acid. James

Hutchison MacGregor (to Courtaulds Ltd.). U. S. 2,417,312 (Mar. 11, 1947).

Wool-dyeing properties are imparted to viscose rayon staple by treatment with guanidine acrylates and formaldehyde. The fibers are treated at pH 8, hydroextracted to 100% liquid content, dried and heated to 140°C for 10 min. It is claimed that 50–50 blends of treated staple with wool may be dyed with chrome colors so that each fiber is dyed to approximately the same depth. It is specified that the salts used are guanidine salts of alpha-beta unsaturated carboxylic acids which are devoid of amino groups. A. R. Martin

Text. Research J. July 1947

Crush-Resistant Fabric

Woven textile fabric. William S. Nutter (to Goodall-Sanford, Inc.). U. S. 2,417,320 (Mar. 11, 1947).

A springy crush-resistant fabric. The weave is a balanced plain weave. The warp is a two-ply yarn; one ply is a low-count cotton yarn, the other a high-count (cotton count) filament rayon. The rayon yarn is "buried" in the low-count cotton ply. The filling is a blend containing about 3 parts mohair and one part staple rayon. A. R. Martin

Text. Research J. July 1947

Fused Fabrics

Process of producing a textile product. Worth Wade (to American Viscose Corp.). U. S. 2,417,453 (Mar. 18, 1947).

Vinyl resin yarns are coated with a urea-formaldehyde butanol ether resin in the thermoplastic state which contains a plasticizer and catalyst. The coating is cured below the shrinkage temperature of the vinyl fiber. Fabrics made from this yarn may then be ironed at temperatures in excess of the melting point of the core yarn. A. R. Martin

Text. Research J. July 1947

Upholstery Fabric

Flat woven fabric and method of making the same. William S. Nutter (to Goodall-Sanford, Inc.). U. S. 2,417,319 (Mar. 11, 1947).

A broken twill fabric made from a mohair face warp, a cotton or rayon back warp, a cotton or rayon cord warp and mohair filling. The mohair yarns are large compared to the cotton or rayon yarns and give the face of the fabric a mohair-like character. A. R. Martin

Text. Research J. July 1947

Water-Sensitive Fabrics

Production of textile materials which are sensitive towards water. John Guilfoyle Williams and Leonard Krause (to British Celanese Ltd.). U. S. 2,417,535 (Mar. 18, 1947).

A fabric with very low wet strength but unimpaired dry strength is prepared by treating a cellulose acetate with 0.5% HCl, squeezing it, letting it stand overnight at room temperature, and then placing it in an atmosphere of 100% R.H. at 37°C. for 4–6 days. The excess acid is neutralized with NH_3 gas.

Text. Research J. July 1947 A. R. Martin

Processing Long Fibers

Apparatus for manufacturing long fiber into yarn. Samuel E. Thomas and Walter R. Guthrie (to Lehigh Spinning Co.). U. S. 2,418,996–998 (Apr. 15, 1947).

U. S. 2,418,996—Long fibers are fed into Good's machine in discontinuous lengths and under precision control to produce uniform weight and collected under pressure in a continuous roll or lap. U. S. 2,418,997—A roll former for use in conjunction with U. S. 2,418,996. U. S. 2,418,998—A device for feeding laps of long fibers directly to a breaker card. A. R. Martin

Text. Research J. July 1947

Proofing Treatment

Manufacture of water-resistant uninflammable organic fibrous materials and product. Frederick F. Pollak. U. S. 2,418,525 (Apr. 8, 1947).

Fabrics are treated with an aqueous solution of pyrophosphoric acid and melamine pyrophosphate is precipitated on and within the fibers. The salt is insolubilized by drying at 120–140°C. The treated fabric is said to be permanently fire-, water-, and mildew-resistant.

Text. Research J. July 1947 A. R. Martin

Sewing Thread

Thread, yarn, filament, and the like. John Irwin, Jr. U. S. 2,418,771 (Apr. 8, 1947).

A transparent or translucent sewing thread designed for use with colored fabrics. The plastic thread blends with the fabric by appearing to be of the same color. A. R. Martin

Text. Research J. July 1947

Staple-Fiber Opener

Staple-fiber opener. John E. Spalding, and Dan B. Wicker (to American Viscose Corp.). U. S. 2,418,126 (Apr. 1, 1947).

A device for wet-opening staple fiber. A. R. Martin

Text. Research J. July 1947

Multiple Web Loom

Narrow-fabric multiple web loom. William Holt (one-half to J. & N. Philips and Company Ltd.). U. S. 2,416,098 (Feb. 18, 1947).

A narrow-fabric multiple web loom which it is claimed is simpler and less costly to make and maintain than existing looms of the type.

Text. Research J. July 1947 A. R. Martin

Wool Modification

Process of treating animal fibers and products thereof. Milton Harris and Wilbur I. Patterson (to Textile Foundation). U. S. 2,418,071 (Mar. 25, 1947).

The disulfide linkages of wool are disrupted and converted to thioethers by treatment with thioglycollic acid or beta-mercapto-ethanol at pH 9 and subsequent treatment with alkyl monohalides. The resulting wool is resistant to moths and felting. A. R. Martin

Text. Research J. July 1947